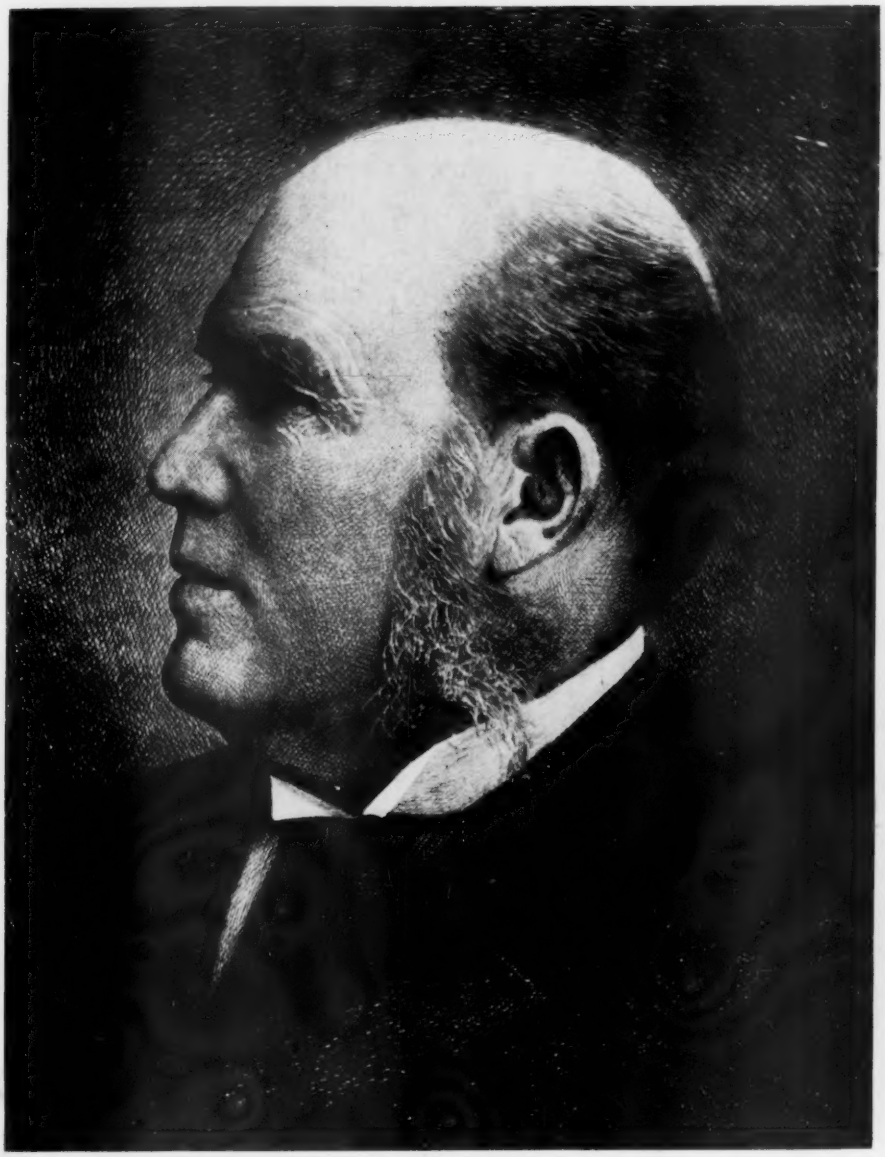
THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

Volume 18 MARCH, 1939 Number 3



For story, see page 109

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Volume 18 March, 1939 Number 3

CONTENTS

Papers

Symposium on "Steel Mill Pouring Pit Refractories"
I, Refractories for Bottom Cast Pouring—W. C. Kitto ... 79
II, Study of Factors Influencing Pouring Rates of Nozzles—E. C. Hite and E. E. Callinan ... 80
III, Pouring Pit Refractories as a Source of Nonmetallic Inclusions—D. L. McBride ... 86
IV, Memoir about Steel Pouring Refractories—C. L. Kinney ... 87
Suggested Insulating Firebrick Specifications—W. R. Kerr ... 93
Improved Machine Shows Different Forms of Failure of Clay Bodies in Torsion—R. P. Graham and J. D. Sullivan ... 97

Activities

American Ceramic Society Forty-First Annual Meeting: Evening Program Activities—Invitation to Chicago Tribune Tower—Ceramic Manufacturing Plants in Immediate Chicago Area ... 101
Golden Gate General Meeting, San Francisco, Calif.: Committees—Ceramic Exhibit ... 102
Membership Record Page to February 18, 1939 ... 103
New Members—Roster Changes ... 104
News of Members: Committee on Pharmaceutical Glass—National Paving Brick Association ... 104
H. C. Kleymeyer Greetings ... 105
Roger Rowland Honored ... 105
Necrology: G. W. Goudy ... 105
Audit Report of American Ceramic Society for 1938 ... 106
Local Sections: Baltimore-Washington—Pittsburgh—Northern California ... 106
St. Louis ... 107
Ceramic School Notes: Ohio State University—Virginia Polytechnic Institute—Rutgers University ... 107
Porcelain Enamel Institute: P. L. Smith, Research Associate—Proceedings of Third Annual Forum ... 107
Fellows of American Ceramic Society: List of Officers, 1930–1939 ... 107
Institute of Ceramic Engineers ... 108
Edward Orton, Jr., Ceramic Foundation: Fundamental Researches Financed—A. W. Helz Employed—Balance Sheet for 1938 ... Advertising Section 209

Ceramic History

Armour Institute of Technology Historical Sketch ... 109

Communications

Use of Santomerse to Reduce Surface Tension and Decal Watermarking—E. H. Lintz ... 110
Creative Development Vision in Ceramic Industries—R. C. Purdy ... 111

Advertisers' Index ... 6

Buyers' Guide ... 9–12

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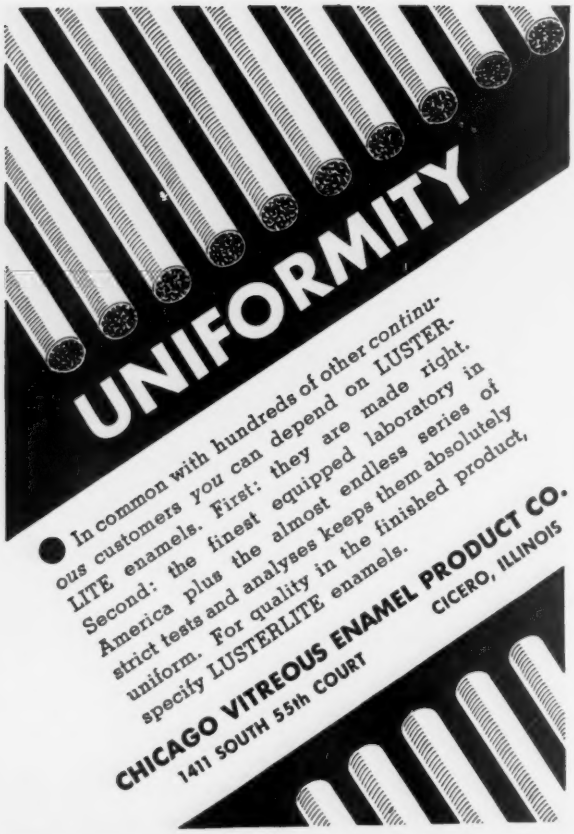
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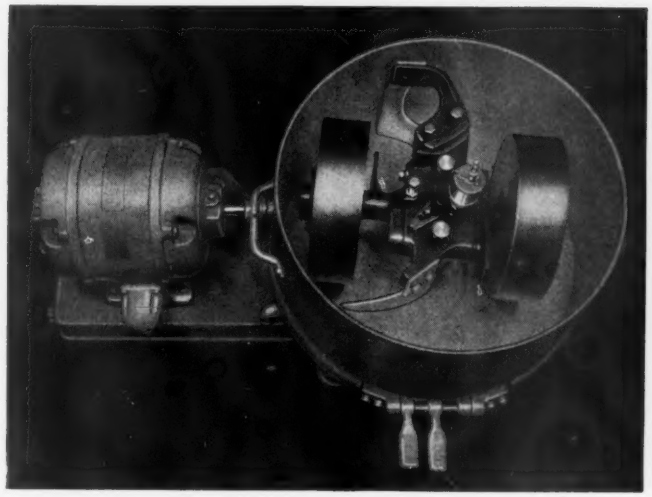

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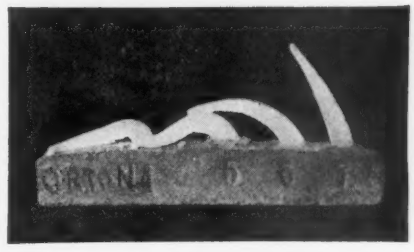

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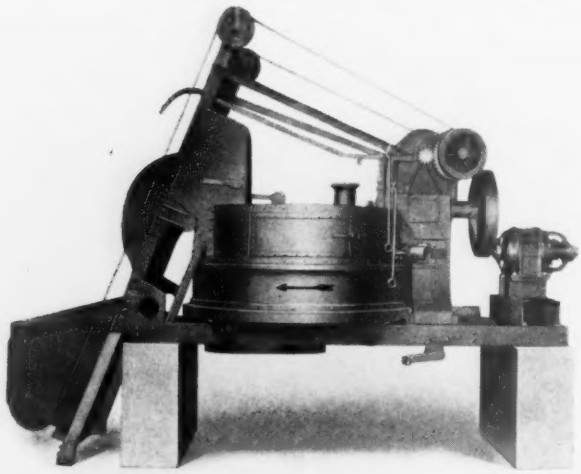

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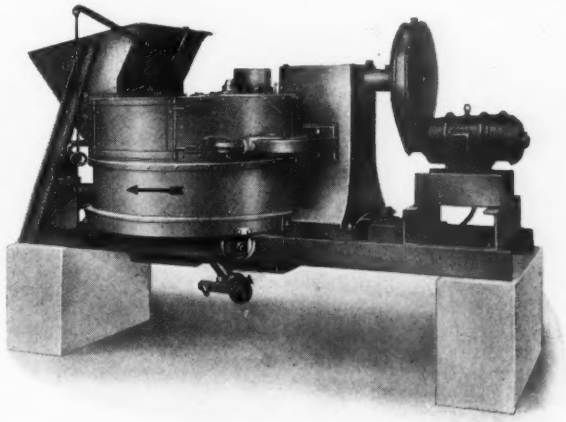

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ALPHABETICAL LIST OF ADVERTISERS

	Page
American Potash & Chemical Corporation	14
American Telephone & Telegraph Co	22
Bethlehem Steel Company	2
Buyers' Guide	9–12
Celo Mines, Inc.	*E110
Ceramic Color & Chemical Mfg. Company	21
Chicago Vitreous Enamel Product Company	2
Corhart Refractories Company	16
Dalton, John P.	*E110
Drakenfeld, B. F., & Co.	Inside Front Cover
Du Pont de Nemours, E. I., & Company	15
Edward Orton, Jr., Ceramic Foundation	3
Frazier-Simplex, Inc.	17
Hammill & Gillespie, Inc.	2
Hartford-Empire Company	8
Hommel, O., Company	3
Kaolin, Inc.	21
Lancaster Iron Works, Inc.	4–5
Maxson, Elwyn L.	13
McDanel Refractory Porcelain Company	14
Metakloth Company	14
Metal & Thermit Corporation	Outside Back Cover
Montgomery Porcelain Products Co.	6
National Engineering Co.	3
Orton, Edward, Jr., Ceramic Foundation	3
Pacific Coast Borax Company	18
Paper Makers Importing Company	13
Pennsylvania Salt Mfg. Co.	7
Porcelain Enamel & Mfg. Company	8
Potters Supply Company	18
Professional Directory	8
Proctor & Schwartz, Inc.	8
Reinhold Publishing Co.	19
Society of Glass Tech.	19
Solvay Sales Corporation	14
Spinks, H. C., Clay Company	Inside Back Cover
Swindell-Dressler Corp.	14
Vitro Mfg. Company	6
Willson Products, Inc.	2
Wilson, H. W., Company	18
Wyodak Chemical Co.	8

* Pages marked E appear in Editorial Section.

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Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Clay (Ball)
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Potters Supply Co.
Spinks, H. C., Clay Co.
The Vitro Mfg. Co.
United Clay Mines Corp.

Clay (Bentonite)
Wyodak Chemical Co.

Clay (Block)
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.

Clay (China)
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
The Vitro Mfg. Co.
United Clay Mines Corp.

Clay—Cleaners, Feeders
Lancaster Iron Works, Inc.

Clay (Electrical, Porcelain)
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Spinks, H. C., Clay Co.
United Clay Mines Corp.

Clay (Enamel)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Metal & Thermit Corp.
Paper Makers Importing Co.
The Porcelain Enamel & Mfg. Co.
Spinks, H. C., Clay Co.
The Vitro Mfg. Co.
United Clay Mines Corp.

Clay (Fire)
Denver Fire Clay Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Potters Supply Co.

Clay (German Vallendar)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Kentucky Clay Mining Co.
The Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.
United Clay Mines Corp.

Clay Miners
Maxson, Elwyn L.
Paper Makers Importing Co.
Spinks, H. C., Clay Co.
United Clay Mines Corp.

Clay (Potters)
Denver Fire Clay Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Spinks, H. C., Clay Co.
United Clay Mines Corp.

Clay (Process Equipment)
Lancaster Iron Works, Inc.
National Engineering Co.

Clay (Sagger)
The Hommel Co., O., Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Potters Supply Co.
Spinks, H. C., Clay Co.
United Clay Mines Corp.

Clay-Slip (Albany)
Hammill & Gillespie, Inc.
United Clay Mines Corp.

Clay (Wad)
Kentucky Clay Mining Co.
Potters Supply Co.
Spinks, H. C., Clay Co.
United Clay Mines Corp.

Clay (Wall Tile)
Hammill & Gillespie, Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Spinks, H. C., Clay Co.
United Clay Mines Corp.

Cleaners
Pennsylvania Salt Mfg. Co.
The Porcelain Enamel and Mfg. Co.

Cleaners, Chemical
Harshaw Chemical Co.
Pennsylvania Salt Mfg. Co.

Clocks (Gauge Board)
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.

Cobalt Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Cobalt Sulphate
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Colors
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Concrete (Chutes, Grouters)
Ransome Concrete Machinery Co.

Cones
The Edward Orton, Jr., Ceramic Foundation

Conveying Equipment
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.
National Engineering Co.

Copper Oxide
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Corhart
Corhart Refractories Co.

Cornwall Stone (Imported)
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.

Crucibles (Filter, Melting, Ignition)
Carborundum Co.
Denver Fire Clay Co.
Norton Co.
Potters Supply Co.

Crushers (Clay)
Lancaster Iron Works, Inc.

Cryolite (see Kryolith)
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Pennsylvania Salt Mfg. Co.
The Vitro Mfg. Co.

Crystolon (Refractory Products)
Norton Co.

Cullet, Washing Plants, Incinerators, Crushers
Frazier-Simplex, Inc.

Cutters (Bar)
Ransome Concrete Machinery Co.

Decorating Supplies
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Disintegrators
Lancaster Iron Works, Inc.
National Engineering Co.

Dryer (Pipe Rack)
Lancaster Iron Works, Inc.

Drying Machinery
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.
Proctor & Schwartz, Inc.

Electrocast Refractories
Corhart Refractories Co.

Enameling Equipment (Complete)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Enameling Furnaces
Carborundum Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Electro Refractories & Alloys Corp.
The Hommel Co., O., Inc.
Lancaster Iron Works, Inc.
Norton Co.

Enameling Iron (Sheet)
American Rolling Mill Co.
Bethlehem Steel Co.

Enameling Muffles
Bethlehem Steel Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Electro Refractories & Alloys Corp.
Frazier-Simplex, Inc.
Norton Co. (*Alundum*)

Enameling (Practical Service)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.

Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Enamel Oxide
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.

Enamels (Porcelain)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.

Equipment (Porcelain Enameling)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The DeVilbiss Co.
The Hommel Co., O., Inc.

Exhaust Systems
The DeVilbiss Co.

Feldspar
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Filter Fabrics
Metakloth Company

Fire Brick
Carborundum Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.

Fire Brick—Process Equipment
Lancaster Iron Works, Inc.

Fire Clay
Denver Fire Clay Co.
Spinks, H. C., Clay Co.

Flint
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.

Flint Pebbles
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Floors (Non-Slip)
Norton Co.

Fluorspar
Harshaw Chemical Co.
The Hommel Co., O., Inc.

French Flint
Maxson, Elwyn L.
Paper Makers Importing Co.

Frit
Allied Engineering Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.

Frosting Mixtures
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Fuel Oil Systems and Control, Stokers
Bethlehem Steel Co.
Frazier-Simplex, Inc.

Furnaces
Allied Engineering Co.
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.
Swindell-Dressler Corp.

Furnaces-Enameling
Swindell-Dressler Corp.

Glass Bending Ovens, Glass Decorating Machines
Frazier-Simplex, Inc.

Glass Equipment
Hartford-Empire Co.
Lancaster Iron Works, Inc.

Glass Melting Tanks and Furnaces
Frazier-Simplex, Inc.

Glass Thickness Gauge
Bausch & Lomb Optical Co.

Glaze and Body Spar
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.

Glaze Spar
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.

Goggles
The Hommel Co., O., Inc.
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Gold Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.

Granulators
Lancaster Iron Works, Inc.

Grinding Wheels
Carborundum Co. (*Carborundum and Aloxite*)
Chicago Vitreous Enamel Product Co.
Norton Co. (*Alundum-Crystolon*)

Hearths
Carborundum Co. (*Carbofrax* heat treating)
Corhart Refractories Co.
Electro Refractories & Alloys Corp.
Norton Co. (*Crystolon*)

Hearths (Fused Al_2O_3, SiC)
Electro Refractories & Alloys Corp.

Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Norton Co.

Hoppers (Floor, Tower)
Ransome Concrete Machinery Co.

Hose (Air and Fluid)
The DeVilbiss Co.

Hydraulic Propellers
Denison Engineering Co.

Hydrofluoric Acid
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Iron Chromite
Harshaw Chemical Co.

Iron (Enameling)
American Rolling Mill Co.
Bethlehem Steel Co.

Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Kaolin
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
United Clay Mines Corp.
The Vitro Mfg. Co.

Kellog AA Refractories
Electro Refractories & Alloys Corp.

Kilns, China (Decorating)
Denver Fire Clay Co.
Drakenfeld, B. F., & Co.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.
Swindell-Dressler Corp.

Kilns-(Electric, Circular, Tunnel)
Swindell-Dressler Corp.

Kiln Furniture (Silicon Carbide, Semi-Silicon Carbide) (Refractory)
Electro Refractories & Alloys Corp.
Louthan Mfg. Co.

Kyanite
Celo Mines, Inc.

Kryolith (see Cryolite)
Pennsylvania Salt Mfg. Co.

Laboratory Ware
Norton Co.

Lehr Tile (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Electro Refractories & Alloys Corp.

Lehrs
Frazier-Simplex, Inc.
Swindell-Dressler Corp.

Lehrs (Electric or Fuel Heated)
Frazier-Simplex, Inc.
Swindell-Dressler Corp.

Lehr Loaders
Frazier-Simplex, Inc.

Linings (Furnace Refractory, Block Refractory Plate, Brick, and Tile)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.
The Vitro Mfg. Co.

Lithium Carbonate
Drakenfeld, B. F., & Co.

Loaders (Bucket)
National Engineering Co.

Magnesia (Fused)
Electro Refractories & Alloys Corp.
Norton Co.

Magnesia (Sintered, Calcined)
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel and Mfg. Co.

Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Magnesite Calcined
The Hommel Co., O., Inc.

Magnesium Carbonate
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Manganese
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Manganese Dioxide
Drakenfeld, B. F., & Co.

Manganese (Oxide)
Ceramic Color & Chemical Mfg. Co.
Corhart Refractories Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Masks (Breathing)
The DeVilbiss Co.
Drakenfeld, B. F., & Co.
Willson Products, Inc.

Metals (Porcelain Enameling)
American Rolling Mill Co.
Bethlehem Steel Co.

Microscopes (Polarizing)
Bausch & Lomb Optical Co.

Minerals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Mixers
National Engineering Co.
Ransome Concrete Machinery Co.

Mixers (Batch)
Lancaster Iron Works, Inc.
National Engineering Co.

Mixers (Concrete, Paving, Road Paving, Plaster, Asphalt, Truck, Mortar, Bituminous)
Ransome Concrete Machinery Co.

Mixers (Laboratory)
National Engineering Co.

Mold Sanders
Lancaster Iron Works, Inc.

Muffles (Furnace)
Allied Engineering Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Frazier-Simplex, Inc.
Norton Co.

Muffles (Laboratory)
Electro Refractories & Alloys Corp.

Mullers (Batch)
National Engineering Co.

Mullite (Refractories)
Electro Refractories & Alloys Corp.

Muriatic Acid
Denver Fire Clay Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Pennsylvania Salt Mfg. Co.

Needle Antimony
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Nickel Salts
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Nitrates (Cobalt, Sodium)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Nitre
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Non-Gro Refractories
Electro Refractories & Alloys Corp.

Norbide (Norton Boron Carbide)
Norton Co.

Olivine
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.

Opacifiers
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I. & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.

Overglaze Colors
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co. Inc., R. & H. Chemicals Dept.

Oxides
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.

Palladium Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.

Pins
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Louthan Mfg. Co.
Potters Supply Co.

Pins (Tile Setter)
Louthan Mfg. Co.

Placers (Concrete Pneumatic)
Ransome Concrete Machinery Co.

Platinum Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.

Polariscopes
Bausch & Lomb Optical Co.
Frazier-Simplex, Inc.

Porcelain Enameling Service (Practical)
American Rolling Mill Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.

Porcelain Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
The Vitro Mfg. Co.

Potters Wheels
Denver Fire Clay Co.

Potash (Carbonate)
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.

The Hommel Co., O., Inc.
Solvay Sales Corp.
The Vitro Mfg. Co.

Producer Glass Plants
Frazier-Simplex, Inc

Pug Mills
Lancaster Iron Works, Inc.

Pyrites (Natural Iron Sulphide)
The Hommel Co., O., Inc.

Pyrometer Tubes
Carborundum Co.
Electro Refractories & Alloys Corp.

Pyrometer Tubes (Refractory and Hard Porcelain)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Norton Co.

Pyrometers (Optical, Radiation, Surface, Immersion, Needle)
Pyrometer Instrument Co.

Pyrometric Cones
The Edward Orton, Jr., Ceramic Foundation

Racks, Firing (Refractory)
Louthan Mfg. Co.

Raw Material Handling Equipment
Frazier-Simplex, Inc
Lancaster Iron Works, Inc.

Refractometers
Bausch & Lomb Optical Co.

Refractories
Carborundum Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Louthan Mfg. Co.
Norton Co.

Refractory Materials
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Louthan Mfg. Co.
Norton Co.

Represses (Automatic)
Lancaster Iron Works, Inc.

Respirators
Chicago Vitreous Enamel Product Co.
The DeVilbiss Co.
Drakenfeld, B. F., & Co.
The Hommel Co., O., Inc.
Willson Products, Inc.

Rutile
Ceramic Color & Chemical Mfg. Co
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Vitro Mfg. Co.

Saggers
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.
Potters Supply Co.

Salt Cake
American Potash & Chemical Co
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Pennsylvania Salt Mfg. Co.

Sandblast Helmets
Willson Products, Inc.

Sand Grinder and Sifters
Lancaster Iron Works, Inc.

Saponin
The Hommel Co., O., Inc.

Screening and Magnetic Separators
National Engineering Co.

Selenite of Sodium
Drakenfeld, B. F., & Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Selenium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Setters (Tableware)
Louthan Mfg. Co.

Sheaves (Tower)
Ransome Concrete Machinery Co.

Sheets (Enameling Iron)
American Rolling Mill Co.
Bethlehem Steel Co.

Silica (Fused)
Electro Refractories & Alloys Corp.
The Hommel Co., O., Inc.

Silicate of Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Harshaw Chemical Co.

Silicon Carbide
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.

Silicon Carbide Firesand
Carborundum Co.

Sillimanite Refractories
Denver Fire Clay Co.
Electro Refractories & Alloys Corp

Slab Pushers—Hydraulic
Denison Engineering Co.

Slabs (Furnace)
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.

Soda Ash
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Du Pont de Nemours, E. I., & Co., Inc. R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Pennsylvania Salt Mfg. Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc.. R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Vitro Mfg. Co.

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Metal & Thermit Corp.
The Vitro Mfg. Co.

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Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

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Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
McDanel Refractory Porcelain Co.
Norton Co.

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Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

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Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
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Paper Makers Importing Co.
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Winding Drums
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The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Zircon
Foote Mineral Co.
The Hommel Co., O., Inc.

Zirconia
Ceramic Color & Chemical Mfg. Co.
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PAPERS

SYMPOSIUM ON "STEEL MILL POURING PIT REFRACTORIES"

I. REFRACTORIES FOR BOTTOM CAST POURING

By W. C. Kitto

The papers included in this Symposium were presented at the Refractories Division Autumn Meeting, Bedford Springs, Pa., September 2 and 3, 1938. Gilbert Soler, Steel & Tube Div., Timken Roller Bearing Co., Canton, Ohio, was Program Chairman for this meeting. The papers were received October 13, 1938.

I. Introduction

Because the greater part of bottom casting in this plant is dead-killed steel poured into round ingots, it will be understood that the refractories referred to in this paper are those suitable for this kind of work. To produce these ingots, it is necessary to bottom-cast to secure the required smooth ingot surface. The refractories through which this steel is poured must be capable of withstanding high temperatures and severe erosion of the fast, hot stream of metal.

II. Specifications and Process

The round ingots of dead-killed steel vary in weight from 1250 to 5500 lb. each, and the specifications call for various carbons, ranging from a low of about 0.10 to a high of about 0.50, and from 125 to 130 gross tons per heat; from 10 to 18 groups of ingots are necessary for each heat.

The steel is tapped at high temperature and is poured through a magnesite nozzle, $13^1/_2$ in. long with a bore of $1^3/_8$, $1^1/_2$, or $1^5/_8$ in. Screw-type, large-size graphite stopper heads are used; the teeming temperature is about 2900°F. Pouring metal at this temperature into an average of fourteen groups per heat puts a severe strain on the stopper head and nozzle, but stopper heads are rarely lost and difficulties with a nozzle seldom occur.

The center runner brick is $2^3/_8$ in. inside diameter and $5^1/_4$ in. outside diameter; all other runner brick have $1^1/_2$-in. holes and all outlets are of $1^1/_2$ in. diameter.

The steel is tapped hot enough so that there is no skull in the ladle after the pouring is finished, and it is poured as fast as possible. Regardless of the size of ingot wanted, the pouring rate and the number of ingots per group are so regulated that the volume of metal poured per minute and the rise in the molds is about the same. It should be understood that if the pouring temperature is too high, cracked ingots will result. An expert steelmaker is needed if this type of ingot is to be produced successfully. The steelmaker must be able to judge the temperature of the stream so that he can regulate the teeming to the temperature because hot steel, poured too slowly, will tend to cause brick inclusions in the ingot owing to the brick washing from the excessive erosion of the refractories.

III. Analysis of Nozzles and Runner Brick

An analysis of a dead-burned magnesite nozzle is as follows: SiO_2 3.10, Fe_2O_3 7.44, no MnO, Al_2O_3 2.59, CaO 5.70, Cr_2O_3 0.77, and MgO 80.40%; no ignition loss.

The bell in the nozzle, which is shallow and saucer-shaped, has been in use in this plant for a number of years with good results.

Analyses of three good hollow runner brick (bottom cast brick) are as follows:

	(1)	(2)	(3)
Silica	51.30	56.90	55.92
Iron oxide	2.43	3.72	3.71
Alumina	43.57	35.58	38.59
Lime	0.25	0.30	0.60
Magnesia	0.10	0.15	0.50
Titanium oxide	2.30	3.00	
Porosity	16.59	10.59	
Alkalis			0.48

The runner brick are subjected to a "load test," and if they withstand this test, they are safe to use regardless of chemical analysis, although the ratio of silica-to-alumina content has a lot to do with the quality of the brick. (This matter is more in the line of ceramic experts and the writer will not attempt to discuss it.)

Under the load test, the brick are handled as follows: A 9-in. length of brick is placed on end in a furnace and is subjected to a pressure equal to 25 lb. per sq. in. of its top area;

the heat is gradually increased until a temperature of 2600°F is attained. If the brick shows no deformation under this test, there is little doubt of its quality. These brick must be fired hard enough to have a glazed surface. They must be free from warping and show no signs of cracking. The hole must be smooth and straight so that a full stream will be carried to each ingot and the rise can be maintained at an even rate in all molds on the same group.

NOTE: The quality and workmanship on refractories have been greatly improved in recent years, for which a great amount of credit must be given to John S. Unger, retired, formerly with the Carnegie Steel Company. He has done more to improve the quality of brick and refractories than any other one person in the Pittsburgh district. Through his work with refractories companies and his unceasing efforts, various types of refractories were developed and perfected to such an extent that a great source of worry was lifted from the steel manufacturers. When improvements in refractories are mentioned, Dr. Unger must be remembered for his efforts and the results he gained in developing and improving them.

IV. Conclusions

Well-fitting and tight joints are a necessity in the bottom cast setup. To attain this, the plates must be well cast, with straight and level grooves so that the brick will be held firmly in place. The plates must be carefully and thoroughly cleaned after each pour. The brick ends must be carefully shaped and fired so that they do not become distorted during firing. Skilled workmen are necessary to set up the groups properly. The brick must be set up so that holes are in the exact center of the mold (to prevent splashing or cutting of the mold), and the setup should be such that all of the joints are under the molds, so that they will be held tightly to prevent the possibility of breakouts as much as possible. Too hot teeming temperature will tend to cause breakouts.

A lot of trouble, which is attributed to refractories, can be overcome by proper teeming temperature. It is not impossible to secure refractories that will be capable of meeting almost any teeming condition, insofar as high temperature is concerned, but economy is an important factor because the cost is too high. The next best, which is becoming better as time goes on, must be accepted. By careful teeming and proper teeming temperature, surprisingly little difficulty is encountered.

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II. STUDY OF THE FACTORS INFLUENCING POURING RATES OF NOZZLES

BY EVERETT C. HITE AND E. E. CALLINAN*

I. Introduction

The fact that the nozzle is an important element of the teeming system is attested by the numerous statements to this effect found in the minutes of the yearly Open-Hearth Conference meetings. There have been numerous studies made on nozzles, but there is surprisingly little published data on the results obtained. Hruska,[1] discussing pouring pit problems, has presented data which indicate the importance of nozzles. Beasley[2] has discussed the importance of nozzle design, stopper and rod assembly, and their effects on pouring conditions. As a result, each independent investigator has been forced to feel his way along without the aid of the experience of his predecessors. The authors of this paper hope that there will be more work and publications on this topic, which is fundamentally important to producers of quality steel.

(1) Effect of Pouring Rates

In general, the effect of pouring rates on steel quality may be summarized as follows: (1) poor ingot surface due to scabs resulting from improper pouring rates; (2) undesirable ingot structure caused by unsatisfactory skin thickness or pronounced segregation, which may be due to improper pouring rates; (3) the amount and distribution of inclusions entrapped in the ingot may be affected by various pouring rates; (4) pouring rates affect mold life, which in turn affects ingot surface; and (5) pouring rates to a certain extent determine the presence of a skull in the ladle and the teeming temperature of the last part of the heat.

This study was made to determine the factors affecting pouring rates, and it is hoped that a better understanding of the factors controlling the amount of variation of pouring rates may result in the improvement and control of steel quality. The logical approach to this problem was to determine how pouring rates are affected by various designs and compositions of nozzles under varying service conditions.

II. Procedure

(1) Types of Nozzles

A total of twenty-three brands of nozzles, supplied by ten different refractories companies, were laboratory- and service-tested. These nozzles were divided into two classes, *viz.*, (1) "general-purpose" nozzles made from the usual clays in regular production by the various companies and sold at normal prices, and (2) "special" nozzles, made from special clays or other refractory materials, in some cases by special methods, and sold by the manufacturers as premium nozzles. The "general-purpose" nozzles had pyrometric cone equivalents ranging from cones 16 to 27 and apparent porosities ranging from 10 to 20%. The "special" nozzles ranged from cones 31 to 37 in P.C.E. and from 10 to 28% in apparent porosity.

(2) Service Tests on "General-Purpose" Nozzles

In service testing the "general-purpose" nozzles, it was found that there was a considerable change in pouring rate for a single heat of steel. Ordinarily, the pouring rate would increase until about one-half the heat was poured

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[1] J. H. Hruska, "Finishing the Heat of Steel," *Blast Furnace & Steel Plant*, **24** [3] 151–53 (1933).

[2] H. V. Beasley, "Nozzle and Stopper Rod Assemblies," *ibid.*, **21** [10] 527–29; [11] 581–86 (1933); *Ceram. Abs.*, **15** [7] 208 (1936).

and then decrease for the remaining part of the heat, finishing at a little higher rate than at start of pour. The factors which were considered by the writers as affecting these rates of pour were (1) orifice diameter of the nozzle,

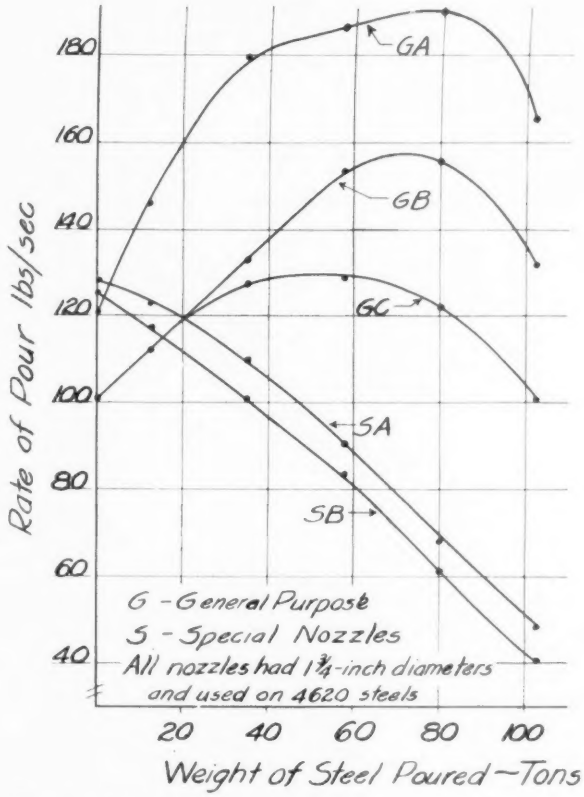

FIG. 1.—Actual pouring rates of alloy steels with various nozzles.

(2) ferro-static head of steel in the ladle, (3) viscosity of the steel, (4) manual control of the stopper rod, and (5) quality of the nozzle.

It was found that the orifice diameter increased throughout the teeming period. The total amount of erosion of the nozzle seemed to be a result of the quality of the nozzle and of the type, temperature, and velocity of the steel. The velocity was controlled by the ferro-static head of steel in the ladle.

When top pouring "big-end-up" ingots, using a full nozzle stream, the ferro-static head of steel in the ladle has a definite effect on the rate of pour. The first part of the heat will pour much faster than the latter because of the larger amount of steel in the ladle at this time.

Theoretically, viscosity of the steel has no appreciable effect on the pouring rate. Under actual service conditions, however, a steel which is quite viscous due to low temperature will pour rather sluggishly, increasing the coefficient of friction, and at times will cause small icicles to build up on the tip of the nozzle. This condition is undesirable from the standpoint of cleanliness.

The manual control of the stopper rod is also an important factor in controlling the rate of pour. Men skilled in this work can teem a heat of steel without any appreciable difference in pouring rate throughout the heat. In doing this, however, it is necessary to increase the over-all teeming time of a heat, which is sometimes objectionable from a practical and quality standpoint. In this study, all pouring rates were obtained by using a full nozzle stream.

(3) Service Tests on "Special" Nozzles

In service testing the "special" nozzles, a considerable variation was found in the pouring rate of a single heat of steel (see Figs. 1 and 2). From these charts, it is evident that the change in pouring rate of the "special" nozzles is quite different from that obtained with the "general-purpose" nozzles. This condition could not be satisfactorily explained by the factors listed under the discussion

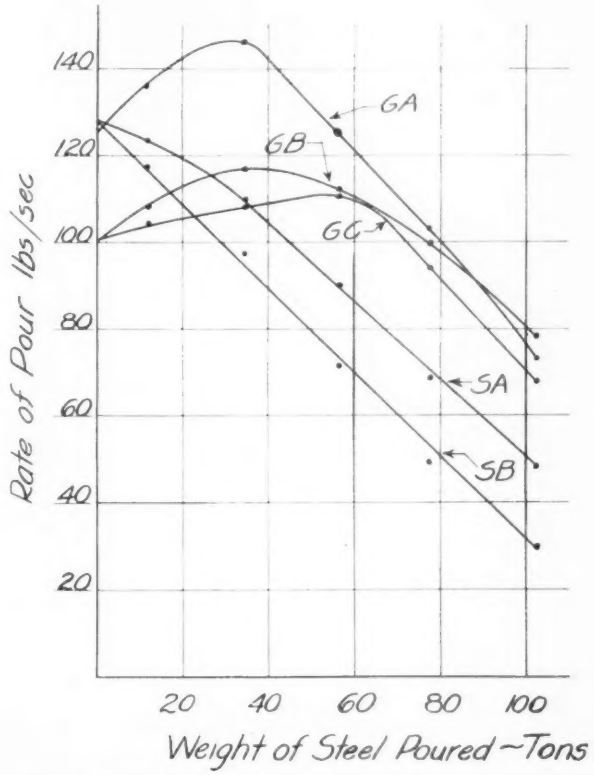

FIG. 2.—Pouring-rate curves from Fig. 1 corrected for constant $1^3/_4$-in. nozzle opening.

on the "general-purpose" nozzles. Accordingly, an effort was made to find some explanation for this decidedly different type of pouring-rate curve which was encountered with the "special" nozzle service tests.

III. Types of Flow in Nozzles

According to the principles of physical chemistry, there are two basic types of flow through orifices, viscous and nonviscous. It has generally been believed that the flow of steel through nozzle orifices is nonviscous in character and follows the formula of a free-falling body, *viz.*,

$$\text{Velocity} = \sqrt{2GZ},$$

or expressed in weight terms,

$$\text{Lb. steel/sec.} = \pi r^2 \cdot d \sqrt{2GZ}.$$

Where r = nozzle radius (ft.).
d = density of steel (lb./cu. ft.).
Z = head of steel (ft.).

This formula expresses the maximum pouring rate which may be obtained. In this case, the viscosity of the steel, nature of the surface of the orifice, and length and contour of the orifice are not taken into account as affecting the pouring rate. Referring to Fig. 3, it may be seen that the actual pouring rates obtained with "general-purpose" nozzles tend to approach this nonviscous type of flow, particularly at the latter part of the heat. To check this, an experiment was made with "general-purpose" nozzles.

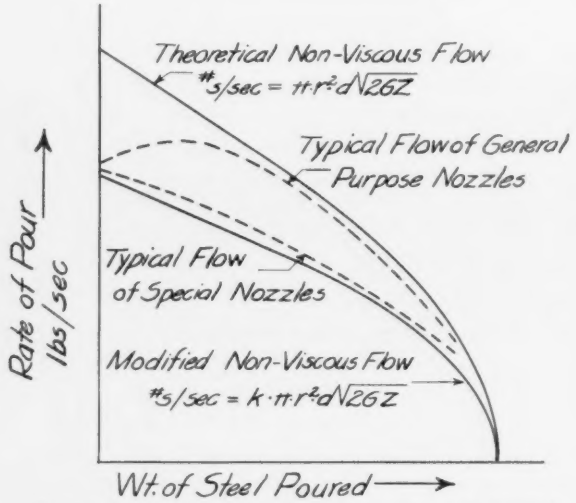

FIG. 3.—Theoretical *vs.* actual flow of steel through ladle nozzles; r = nozzle radius (ft.); d = density of steel (lb./ft.^{3}); Z = head of steel (ft.); k = coefficient of contraction.

Two nozzles of the same composition and same orifice diameter but of different orifice lengths were placed in a double-pour basket, and the same amount of steel was poured through each. There was no difference in the pouring rates of the two nozzles even though one was longer than the other, which indicates that the viscous drag of the steel on the surface area of the orifice is a negligible factor, as expressed by the formula given. This seems to indicate that when this type of flow is obtained, the design of the nozzle orifice, whether long or short, conical or otherwise, does not affect the pouring rate, which is a parabolic function of the cross-sectional area of the nozzle and the square root of the head of steel.

(1) Viscous Flow Formulas

Theoretically, the viscous type of flow, which is found with liquids flowing through capillary tubes, may be calculated by Poiseuille's equation, *viz.*,

$$V = \frac{\pi p r^4 t}{8NL}.$$

Where V = volume delivered.
p = hydrostatic pressure.
r = radius of capillary.
t = time of delivery.
N = viscosity of liquid.
L = length of capillary.

A correction, however, must be introduced into this equation, if a short capillary of large bore is used. This correction must be determined empirically and, according to Bingham,[3] the formula becomes

$$\frac{1.12d}{8\pi LtN} V^2 + V = \frac{\pi P r^4 t}{8LN}.$$

Or resolving and expressing in terms of pounds per second,

$$W^2 + \frac{8\pi LN}{1.12} \times W = \frac{\pi^2 Z G r^4 d^2}{1.12}.$$

The second term of this formula is so small in comparison to the third term that for all practical purposes it may be disregarded, and the equation becomes

$$\text{Lb. steel/sec.} = W = \pi r^2 d \sqrt{\frac{GZ}{1.12}}.$$

This equation indicates that the dimensions of a nozzle are so much out of proportion to the dimensions of a capillary tube that the viscosity of the steel has no appreciable effect on the rate of pour. According to Desch,[4] the viscosity of molten steel is less than that of water. Because the terms of this formula are the same as those found in the formula for nonviscous flow but of slightly lower magnitude, the theoretical pouring rate will again become a parabolic function of the head of steel in the ladle and of the cross-sectional area of the nozzle. Figure 3 also shows that the pouring rates obtained with the "special" nozzles are consistently lower than those obtained with the "general-purpose" nozzles.

It has been indicated by the formula derived from Poiseuille's equation that viscosity and surface area of the nozzle are not the controlling factors in viscous type of flow. Therefore, although a lower rate of flow is obtained with the "special" nozzles, the conclusion must not be drawn that viscous flow exists, but rather that some modification of nonviscous flow is obtained.

(2) Nonviscous Flow

The actual discharge through an orifice very nearly equals the area of the vena contracta multiplied by $\sqrt{2GZ}$. The ratio of the area of the vena contracta to the area of the orifice is called the coefficient of contraction. This coefficient will vary with various design of orifices, approaching unity in an orifice which provides for streamline flow. The design of the nozzles used in these tests does not provide for streamline flow. The examination of a large number of "general-purpose" nozzles after service indicated that they had eroded so as to produce streamline flow. This theory provides a satisfactory explanation for the increase in rate of pour which occurred during the first part of the teeming with "general-purpose" nozzles.

In the case of the "special" nozzles, the orifice is not appreciably eroded to a streamline design. As a result, the coefficient of contraction which produces a lower rate of pour applies throughout the entire teeming period (Fig. 3). This seems to be the principal factor modifying the true nonviscous type of flow.

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[3] E. C. Bingham, Fluidity and Plasticity, pp. 8–16. McGraw-Hill Book Co., Inc., New York, 1922; *Ceram. Abs.*, **1** [6] 172 (1922).

[4] C. H. Desch, "Physical Factors in Casting of Metals," abstracted in *Metal Progress*, **32** [2] 144 (1937).

Another factor is the tendency of the "special" nozzles to exhibit pronounced wetting of the orifice area. This causes objectionable build-up, increases the frictional resistance, and may decrease the cross-sectional area of the nozzle. Both types of nozzles have their orifice areas wetted, the "general-purpose" nozzles, however, to a much lesser degree. The writers' conception of this difference in the wetting tendency is that because all of the "general-purpose" nozzles have a P.C.E. of cone 27 (2921°F) or lower (see Table I) and a corresponding softening point well below this point, the temperature of the steel is sufficient to soften the nozzle, and the actual wetted portion of the nozzle is washed into the ingot along with the metal stream. This sloughing off of the orifice area tends to lower the frictional resistance and to nullify the building-up tendency.

Conversely, the "special" nozzles, which have a P.C.E. of cone 31 (3056°F) or higher with softening points above the teeming temperature of the steel, are not washed away in service. As a result, the wetted portion of the nozzle remains and causes the build-up and increases the frictional resistance. The amount of build-up is further dependent upon the porosity, thermal conductivity, and grain size of the nozzle, as well as the type of steel.

FIG. 4.—Typical "general-purpose" nozzle before and after service.

IV. Summary

In the case of "general-purpose" nozzles, the original orifice design, whether long or short, tapered or otherwise, will have but a small effect in controlling pouring rates because soon after the start of the teeming period, the original orifice contour erodes to a streamline design. By providing an original streamline orifice, however, it would be possible to teem the first part of the heat at a higher rate of pour, using the same size nozzle. The objectionable feature of a "general-purpose" nozzle is the excessive erosion (see Fig. 4).

In the case of "special" nozzles where the original orifice contour is maintained, the shape of the original orifice is important in controlling the rate of pour during the entire teeming period (see Figs. 5 and 6). The design of the orifice, however, will affect only the slope of the pouring-rate curve, which will be a parabola. With a streamline orifice, there will be quite a reduction in the amount of build-up on the tip of the nozzle because maximum velocity and a full stream will be obtained at the tip. The streamline orifice should thus provide a more desirable type of stream, but it will still give a parabolic pouring curve. This type of curve is not desirable because there is considerable variation in pouring rate between start and finish of teeming.

(1) Ideal Pouring Rate

The ideal pouring rate is generally believed to be one which will be uniform throughout the entire teeming period. According to the formula, the velocity at the vena contracta varies as the square root of the head of steel in the ladle, and as a result the velocity decreases during the teeming period. To maintain a uniform rate of pour

throughout the heat, it would be necessary to increase the area of the vena contracta at the same rate as the loss of head decreases.

On the basis of these observations, it seems that to obtain a nozzle which will most nearly approach this desired pouring rate curve the nozzle should have a refractoriness between that of the two types discussed in this paper. This will provide for a nozzle which will erode only enough to compensate for the loss of head in the ladle. Such a nozzle should also have a modified streamline orifice which would tend to produce a uniform pouring rate as the nozzle eroded out. This modified streamline orifice should also tend to minimize the amount of build-up on the tip of the nozzle. The final design of the nozzle will be further dependent upon the effects which will be produced by differences in thermal conductivity, porosity, grain size, and general workmanship of the finished nozzle.

V. Conclusions

In conclusion, the authors wish to emphasize that the thoughts and concepts presented in this paper are not necessarily final. These are factors, however, which should be given careful consideration when designing nozzles. In their own work, they expect to consider these fundamental concepts, or future modifications, in an attempt to arrive at a nozzle that will produce optimum pouring conditions.

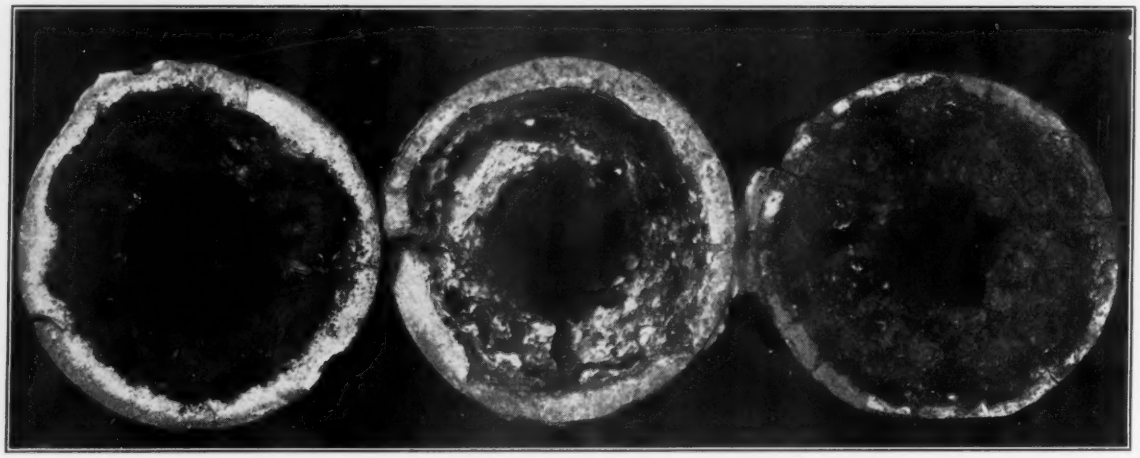

FIG. 5.—*Left to right,* two different "general-purpose" nozzles and a "special" nozzle after service test in same type of steel.

FIG. 6.—*Left,* "special" nozzle before and after use; *right,* "general-purpose" nozzle before and after use. Both nozzles used to pour same amount and type of alloy steel.

TABLE I

"General-purpose" nozzle	P.C.E.	Absorption (%)	Porosity (%)	1315 D* Cut out† (in.)	1315 D* Penetration‡ (in.)	4615* Cut out† (in.)	4615* Penetration‡ (in.)	Remarks
GA	16–20	6–10	13–20	1 3/4	2	1	1 1/2	No build-up; excessive erosion, non-uniform in quality
GB	17	4.5	10.1			1/2	3/4	Less erosion than GA; tendency of black head to stick
GC	26–27	7.0	15.4	5/8	3/4	3/8	1/2	Slight build-up on cold heats; otherwise O. K. More satisfactory than GA
GD	17	6.25	13.9	1 1/4	1 3/4	3/4	1 3/4	About same as GA
GE	20	9.7	19.8			3/4	1/2	Slightly better than GA; tendency to build up
GF	23	9.1	18.8			3/4	1/2	Excessive build-up and spraying
GG	20–23	7.25	16.7	3/4	1	1/2	1/2	More satisfactory than GA
"Special" nozzles								
SA	35	11.5	28.1	1/8	None	1/16	None	Worked fairly satisfactorily
SB	37	6.7	16.1	3/8	"	1/8	"	Built up on tip on cold heats; satisfactory on hot heats
SC	35	6.9	15.3			1/8	"	About same as SB
SD	33	6.8	15.2			1/8	"	" " " "
SE	31	6.9	15.3			1/8	"	" " " "
SF	37	12.9	25.2			1/8	"	Excessive build-up
SG	34	14.0	26.6	1	1/2			Excessive build-up and spraying; cracked in service
SH	32	13.7	25.3	1	1/2	1/4	"	Excessive build-up and spraying
SI (graphite)						None	"	Worked satisfactorily in double-pour basket
SJ (clay-graphite)						1/8	"	Very satisfactory in 30-ton heats
SK	35	11.3	27.9			+1/8	"	Excessive build-up and spraying
SL	37	11.0	24.3	3/8	None			Excessive build-up
SM	37	10.9	24.2	1/2	"			" "
SN	37	Rifled						Rifling caused nozzle to spray excessively
SO	34	9.6	21.0	1/2	"	1/8	"	Built up on tip on cold heats; satisfactory on hot heats
SP	31	4.7	10.6			1/4	"	Better than SO; slight tendency to build up on cold heats

* 1315 D and 4615 = S.A.E. classifications for alloy steels.
† Cut-out is average amount of increase of orifice diameter of nozzle.
‡ Penetration is average depth black head penetrated seat of nozzle.
NOTE: These data were compiled from summary of the individual service test reports of each nozzle; each type of nozzle was service-tested on 2 to 25 heats, depending on the possibilities which it showed.

III. POURING PIT REFRACTORIES AS A SOURCE OF NONMETALLIC INCLUSIONS

By D. L. McBride

Abstract

The erosion of the tapping spout, reaction of the metal with the ladle brick or stopper-rod sleeve brick, and erosion of the nozzle tend to introduce nonmetallic matter into the steel. The use of chrome-magnesite tapping spouts in conjunction with ladle refractories, which are highly resistant to erosion as well as to slag and metal attack, would do much to eliminate pouring pit refractories as a source of nonmetallic inclusions.

I. Introduction

One of the most vital problems facing the manufacturer of quality steels is the elimination of nonmetallic inclusions, or "seams." The composition of these inclusions varies widely, ranging from the simple oxides of iron, manganese, silicon, or aluminum to complex mixtures of these oxides. The sources of these oxides are numerous, but the exact responsibility of each source is difficult to determine. Recent work[1] has indicated that these inclusions can result from reaction of the metal with the pouring pit refractories. There are definite sources other than pouring pit refractories,[2] such as melting practice, deoxidation practice, and pouring pit practice. Much work has been devoted to determining the exact effect of these other causes, and positive improvement has been made. Occasionally, however, a heat occurs which has a tendency to be undesirably dirty, and this condition has been frequently traced back to a bad pouring practice due to the failure of the pouring pit refractories to function properly.

The difficulty involved in studying high-temperature reactions has impeded progress, and it has been necessary to study this question by analogy. Unfortunately, such methods often lead to erroneous conclusions and unfounded prejudices; it is safe, however, to say that bad pouring practice is an important contributory source of both surface and internal seams and that the degree of perfection attained in the pouring pit is closely related to the quality of the refractories involved. Because it is impossible to say which refractories are the most serious offenders, the various types will be discussed in the sequence of operation rather than in the order of their probable importance.

II. Refractories for Tapping Spout

The tapping spout suffers serious erosion under the heavy impact and high velocity of the metal as it leaves the furnace. Because the spout is built up with loam, the eroded portion must be carried into the ladle by the metal, and unless it is eliminated from the metal by levitation while still in the ladle, it will eventually be carried into the mold and thus be found in the finished product as aluminum-silicate inclusions.

The alternative is the use of basic refractories in the construction of the spout; the use of magnesia or chrome-magnesite linings in the spout is sometimes thought to be essential for the production of clean steel. A comparison of results on seven heats, on which a chrome-magnesite spout was used, with the results from eighty-six heats on which a loam spout was used, showed no difference in cleanliness. This should not be taken as an argument against the use of chrome-magnesite spouts, for it is possible that, with a larger number of heats, an average improvement might be noted. The important point is that the use of a basic refractory as a lining for the spout does not, in itself, guarantee freedom from nonmetallic inclusions.

III. Ladle Refractories

All of the refractories in the ladle may act directly or indirectly as contributory sources of nonmetallic inclusions. The ladle brick, stopper-rod sleeve, and nozzle are exposed to a high temperature and chemical attack by the steel for approximately an hour. Körber[1] recently has shown that silica brick in contact with liquid steel may be attacked to a considerable extent. In clay refractories containing a large amount of fluxing materials, attack by the metal is more severe and is roughly proportional to the amount of fluxes present. In addition, the ladle and sleeve brick, which are generally acid refractories, are in contact for some time with a basic slag, and this slag is active in its corrosion of the refractory. The amount of ladle brick eroded by the metal and slag varies between $^1/_2$ to $^3/_4$ brick per ton of steel produced,[3] and if it is assumed that the major attack is by the metal, between 3.5 and 5.5 lb. of refractories per ton of steel are introduced into the metal by the brick-metal reactions. If all of this refractory material is carried into the mold, 0.015 to 0.023% by weight of nonmetallic inclusions, containing Al_2O_3 and SiO_2, would be found in the solid steel.

The requirements for stopper-rod sleeve brick are somewhat more severe than those for ladle brick, although both are exposed to the metal and slag for the same length of time. The purpose of the sleeve brick is to protect the stopper rod from the intense heat of the metal. When the sleeve brick fails to perform this service satisfactorily (which happens occasionally), the result is a leaking or running stopper, which is objectionable because of (1) the industrial hazard created by the wild metal, (2) scabs on the surface of the ingot caused by the wash of metal down

[1] F. Körber, "Influence of Impurities on Reactions between Iron Melts, Iron-Manganese Silicates, and Solid Silica," *Stahl u. Eisen*, **57** [48] 1349–55 (1937); *Ceram. Abs.*, **17** [6] 233 (1938).

[2] L. F. McCombs and Morris Schrero, Bibliography of Nonmetallic Inclusions in Iron and Steel. Published by Metallurgical Advisory Board to Carnegie Inst. Tech., *Coöperative Bull.*, No. 70, 320 pp., 1935; Pittsburgh, Pa.; *Ceram. Abs.*, **15** [11] 329 (1936).

[3] H. M. Kraner, "Development of a Slagging Test for Refractories," *Metals & Alloys*, **9** [4] 79–83 (1938); *Ceram. Abs.*, **17** [8] 280 (1938).

the side of the mold as the ladle is moved into position, and (3) the increased number of nonmetallic inclusions, probably the result of oxidation of the surface scabs and the partial solution of these scabs as the metal rises in the mold.

The properties of the ideal sleeve brick, therefore, are (1) resistance to thermal shock, (2) resistance to slag and metal attack, and (3) low thermal conductivity. Unfortunately, the ordinary clay sleeve brick meets only the first and third requirements satisfactorily. There is an urgent need for the development of a clay sleeve brick which can withstand slag and metal attack without impairing its resistance to thermal shock or its low thermal conductivity.

IV. Nozzles

The erratic performance of nozzles is one of the most distressing factors encountered in the production of high-quality steels. An excessive erosion or a nonuniform erosion of the nozzle by the metal stream is undesirable. Nonuniform erosion of the nozzle tends to develop a canted or spraying stream, either of which will produce an abundance of surface and internal seams. Cleanliness tests on a group of eighteen heats on which the streams were canted or sprayed indicate how seriously the cleanliness of the steel is affected by these conditions. On these heats, four times as many seams were found as on heats with grade A pouring practice.

The effect of canted pouring streams on the cleanliness rating is more definitely demonstrated by considering the individual ratings on the four sides of the test, corresponding to the original sides of the ingot. The following results from a heat which was poured with a canted stream demonstrates the condition generally found:

Side	Cleanliness
1	Perfect
2	Very good
3	Bad
4	Extremely bad

This preponderance of seams on one or two sides of the test is observed all too frequently; in fact, this type of distribution of inclusions is generally confined to heats which have a low cleanliness index.

In all fairness, it must be stated that there are other definite factors not necessarily related to refractories which may cause surface or internal seams. The evidence available, however, indicates that at times pouring pit practice and pouring pit refractories may be an important source of inclusions. The use of a denser, higher refractory hard-fired clay brick or the development of a refractory which is not attacked by the slag or metal would do much to eliminate pouring pit refractories as a source of nonmetallic inclusions.

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IV. MEMOIR ABOUT STEEL POURING REFRACTORIES

By C. L. Kinney

I. Introduction

The basic open-hearth process produces 90.3% of the steel ingots made in the United States, and it also uses at least this percentage of all steel pouring refractories. Consequently, this membir relates only to steel pouring refractories used in basic open-hearth practice.

The past two decades have witnessed notable advances in every aspect of the basic open-hearth process except in pouring refractories.

Unit production of steel ingots has increased, furnace campaigns have lengthened, fuel consumption has steadily decreased, and the uniformity of steel qualities and the diversity in the grades of steel have markedly increased.

Going hand in hand with these changes are the realities that (1) the quantity of steel tapped into ladles has increased by not less than 50%, (2) teeming time has increased more than this, (3) although casting and teeming temperatures, in general, have not greatly increased, more low metalloid steel, as well as other grades, is made, and these are cast and teemed at temperatures higher than the average and in company with markedly corrosive slags.

Notwithstanding all of these aggravated service conditions, the ladle brick, stopper rod sleeves, and nozzle brick which are in general use today, are better only in a limited degree than those made twenty years ago. In consequence, the average steel in the average ladle initially contains not less than 0.28% of its weight in the form of superadded eroded fire clay or its derivatives.

II. Types of Steel Inclusions

All steels contain inclusions of two general types, *viz.*, those produced by deoxidation reaction, "indigenous," and those not so produced, "exogenous."

"Exogenous" inclusions constitute a not inconsiderable portion of all inclusions embedded in steel; and, because petrographic and chemical analyses of this portion suggest that "exogenous" inclusions are largely of refractory ancestry, it becomes plain that the wear and other failures of steel pouring refractories give rise to more of the nonmetallics found in steel than is generally conjectured.

The wear of nozzle brick and nozzle wells probably constitutes between 3 and 5% of the total eroded refractories, and because this is plainly manifested as so-called nozzle drips and enlarged nozzle bores, there follows the natural but unproved assumption that the erosion in these regions is the dominant cause of "exogenous" inclusions.

Nozzle-brick softening and erosion produce inclusions and metallic oxides because eroded approach channels and nozzle bores cause turbulent and divergent jet flow and splashes.

All nozzle brick, moreover, crack in varying degrees, either during the drying period which precedes tap and teem or during teeming. These cracks extend outward, equidistantly from the nozzle bore wall and at angles of about 120° to the axis of the bore. They are found in low and high temperature softening-point nozzle brick, and after use they generally contain steel fins or traces thereof.

In the low softening-temperature nozzle brick, the

channeling adjacent to these fins is less than in high softening-point brick, because the steel-filled crack in the former appears to be sealed by softened fire clay which has been forced into the cracks and nozzle bore, principally by stopper head pressure.

Low softening-temperature nozzle brick (P.C.E. 16 to 18) usually provide better nozzle closures than those with softening temperatures of cone 30 and higher, but this advantage is offset by the excessive and uneven bore wear of the first-named and by concurrent steel jet irregularities.

FIG. 1.—Low P.C.E. (16–23) nozzle and graphite head.

Cracks in high softening-temperature nozzle brick do not seal, and channeling occurs in the nozzle and stopper head adjacent to the steel-filled cracks. These channels are largely the cause of leaking pours, concurrent metal oxidation, and nozzle drips.

Insofar as ladle brick and stopper sleeve erosion is concerned, the writer does not propose to debate the involved subject of particle rise through molten steel, but rather to take for granted that the erosion of refractories, in the region extending up about 20% of a ladle depth from the bottom (which is of an order of 0.15% of the weight of the steel contained in the ladle), is not dissociated from the occurrence of "exogenous" inclusions.

It may be argued that, because 0.15% of "exogenous" inclusion in steel is indicated neither by inclusion count nor by inclusion extraction, this 0.15%, *e.g.*, 300 lb. of melted fire clay, must rise through the molten steel to the slag metal interface and there unite with the superposed slag.

The counter-argument is that, for any reasonable rate of particle rise from the region in question, there is some plane in place or time when any normal rate of particle rise will be exceeded by the downward pull of the jet of steel issuing from the nozzle.

Inclusion counts and extractions do not represent the total nonmetallics embedded in the steel because the quantities so estimated relate to internal (not surface or immediately subsurface) nonmetallics.

Frequently surface and subsurface nonmetallics are referable to eroded refractories, and no small portion of these derive from trapped ingot scums, which ordinarily appear on the visible surface of the steel, rising or quiescent in the ingot molds and in quantities suggesting that refractory erosion other than that of nozzle brick and wells is taking place (or has taken place).

If the foregoing counter-evidence is wholly or in part true, it may be suggested that ladle brick and sleeve erosion must contribute materially to the occurrence of surface and subsurface seams with the result that steel conditioning cost is thereby increased.

III. Adequacy of Steel Pouring Refractories

If steel pouring refractories have not been developed to the same levels of adequacy as have many other fireclay refractories used in exacting steelworks service, the reason may reside in traditional assumptions which nearly everyone accepts and hardly anyone tries to prove.

These assumptions are (1) that the service characteristics of these refractories as related to steel qualities and costs are of minor importance; (2) that the cost per ton of ingots for such refractories is the only practicable and appropriate measure of their qualities; and (3) that they can

FIG. 2.—High P.C.E. (27–28) nozzle showing poor shutoff.

be manufactured outside the ambit of ceramic technology and technological control and without reference to the technologic aspects of service environment and service failures.

That which follows is presented as information which may assist the steel pouring refractories manufacturers and other interested ceramists to take such practical steps as are necessary to improve the present types of steel pouring refractories.

IV. Nozzles

All nozzles crack in service to a greater or lesser degree. First, during the drying of the rammed well, the nozzle brick is usually subjected to thermal shock which produces either visible cracks or invisible planes of weakness. Although more careful heating would decrease such cracking, the practical need here is for less sensitive nozzle brick. Cracking, moreover, occurs when the steel first enters the ladle or the nozzle because the preheated nozzle brick has cooled to or below its sensitive range during the elapsed time from end of preheat to furnace tap.

Practically all nozzles crack because of one or the other cited circumstances or a combination of these, with the result that the user at the present time has only the choice between a cracked low P.C.E. nozzle, which gives good nozzle closure and marked erosion, or a cracked high P.C.E. nozzle, which results in poor nozzle closure, the associated open or semiopen pour, and less erosion but more chill formation.

Figure 1 shows a cone 17 nozzle after service; the nozzle seat has softened sufficiently to insure sealing off all cracks and hence good shutoffs. Figure 2 shows a cone 28 nozzle, which has not softened sufficiently to seal the cracks, and infiltration of steel is evident. Figure 3 shows another cone 28 nozzle with the typical cracking and channeling common to this type.

It would be expected that the desirable properties of the lower P.C.E. nozzle would be offset in part by its greater erosion during pour. Table I shows erosion data from sixteen low P.C.E. nozzles pouring 150-ton heats.

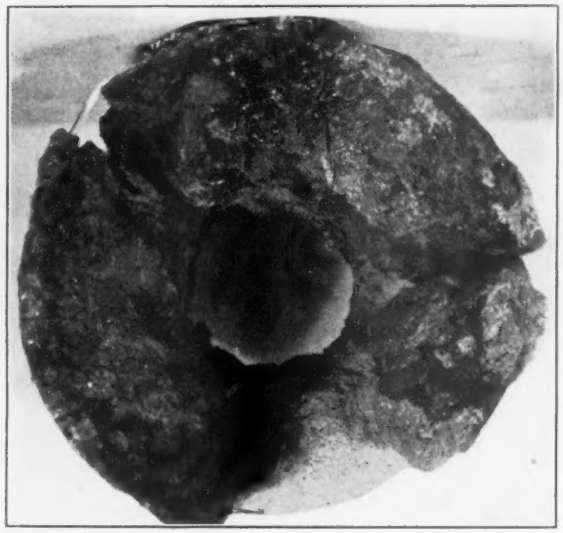

FIG. 3.—Erosion along cracks of high P.C.E. nozzle.

The erosion exhibited in Table I adds from 3 to 5 lb. per heat of eroded refractory to the steel ingots, which is approximately equivalent to 0.0012% of the total ingot weight.

Furthermore, the eroded bore of the low P.C.E. nozzles is usually elliptical, and this suggests antecedent cracking, subsequent channeling, and aggravated turbulent flow.

Bore erosion in more refractory nozzles (above cone 28) is notably less than in nozzles softening at cone 17. But more refractory nozzles also crack, the cracks do not seal (as do those in cone 17 nozzles), channeling is aggravated, nozzle closure is markedly impaired, and concurrently nozzle "drips" or "chills" are formed (Fig. 4), which choke the bore and deflect the nozzle jet.

TABLE I

	Original bore diameter (in.)	Used bore diameter (in.)	Original bore volume (in.³)	Used bore volume (in.³)	Bore volume increase (%)
Maximum	2	3.30	29.8	100.34	236.7
Minimum	2	2.63	29.8	68.22	128.9
Geometric mean	2	2.95	29.8	82.80	174.7

FIG. 4.—Nozzle drips formed on lower part of nozzle.

This action leads to the conclusion that the road toward improved teeming lies in the direction of nozzle brick which will combine vastly improved resistance to thermal shock with notably lessened erosion and other characteristics which will insure positive nozzle closure by the stopper head.

The problem of developing and commercially manufacturing nozzle brick, which will fulfill these requirements, can not be approached empirically and must eventually be solved by intensive ceramic research. Experiments with refractory materials and mixtures with low thermal expansion are indicated.

V. Ladle Brick

Ladle brick currently used in open-hearth practice may hardly be classed as a refractory brick. Yet these must withstand the erosive attack of steel (at temperatures of 2850° to 2900°F) and of the accompanying slag. Most of these brick are made from a plastic clay containing about 60% SiO_2, 25% Al_2O_3, and from 5 to 10% fluxes. Such brick have fusion points of cones 14 (2552°F) to 17 (2687°F), porosities between 14 and 18%, and densities from 1.20 to 1.27 oz. per cu. in.

An important characteristic of low P.C.E. ladle brick is the bloating which occurs at relatively low temperatures, and the brick giving the best service has a 30% linear expansion when reheated to 2350°F for $4^1/_2$ hours.

It is apparent that in this type of ladle brick uniformly fine bloating (Fig. 5) is an important indication of increased ladle lining life. This longer life may be accounted for by the facts that (1) a marked order of bloating prevents slag and metal ingress at brick joints, (2) bloated, low P.C.E. brick are plastic enough to flow when subjected to molten steel temperature and a pressure of about 30 lb. per sq. in., which is present in the lower part of large ladles, and (3) this plastic flow further seals brick joints and makes a relatively smooth inner brick lining from which ladle skulls may be readily removed.

Brick of the high P.C.E. type, ranging from cones 28 to 37 and between 30 and 70% Al_2O_3, made by dry-press, stiff-mud, and super-duty processes, have been experimentally used, and the indications are that, as appraised in terms of cost per ton of ingots, complete ladle lining with these brick can not compete commercially with the best of the low P.C.E. type.

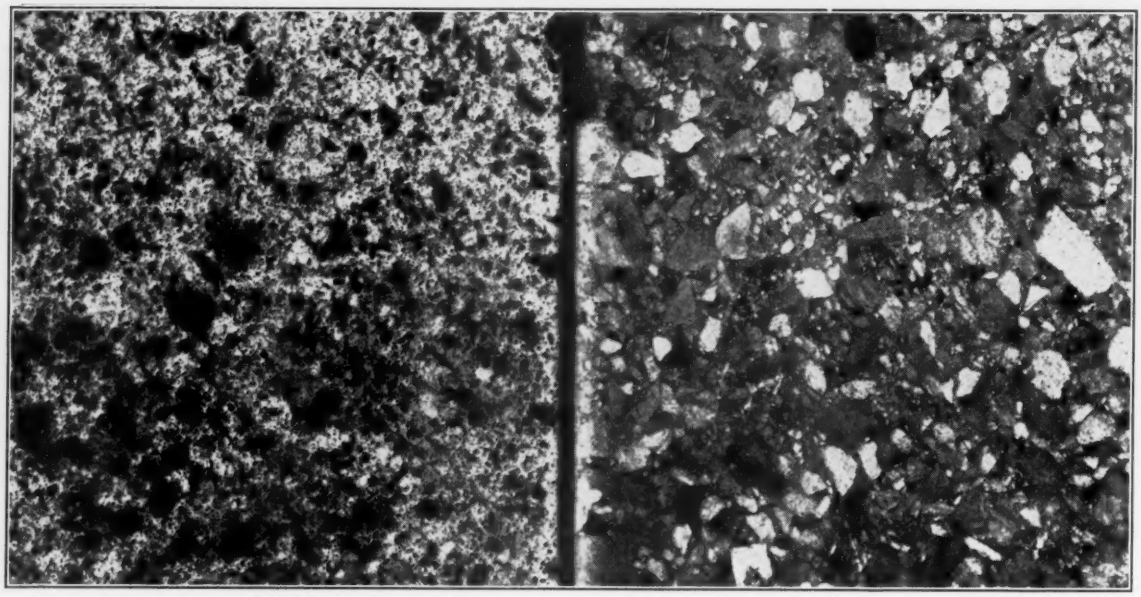

FIG. 5.—Cone 16 ladle brick before and after reheat to 2350°F in 2 hr., held for 4½ hr.

The major shortcoming observed in most high P.C.E. brick is service shrinkage as contrasted with low P.C.E. bloating. Shrinkage obviously results in relatively open brick joints. Slag and steel invade these joints, and this in turn is followed by progressive heat-to-heat joint erosion. Eventually the stringers of steel imbedded in the eroded joints tend to increase skull formation, the difficulty of removing skulls, and the consequent premature breakup of the lining.

FIG. 6.—Low and high P.C.E. brick from same section of ladle; *left*, P.C.E. 16, porosity 20%; *right*, P.C.E. 31, porosity 14%.

Because the softening temperature of the usual low P.C.E. ladle brick is generally 200° to 300°F below the tapping temperature of the steel, it would seem probable that a marked improvement in lining service should follow the use of high P.C.E. linings.

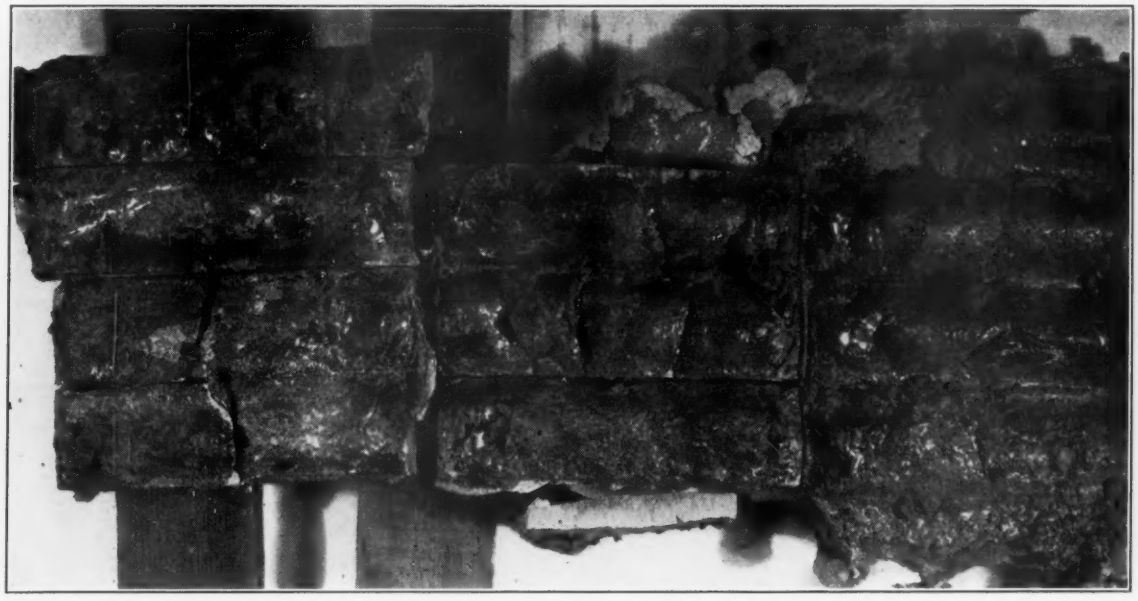

FIG. 7.—Characteristic erosion of refractory brick: *left*, P.C.E. 29, porosity 19%; *center*, P.C.E. 31, porosity 10%; *right*, P.C.E. 26, porosity 20%.

The low porosity and excellent volume stability which typify the best of super-duty fireclay brick lessen the cited difficulties to some extent. But the laying of any of the high P.C.E. and super-duty brick with several types of high-temperature cement has not perceptibly minimized joint erosion.

FIG. 8.—Characteristic erosion of cone 30 brick, porosity 19%.

Figure 6 exhibits the characteristic erosion of high and low P.C.E. ladle brick. In this example, both types of partial lining were removed after thirteen heats, which was the service limit of the cone 16 brick. The middle joint between the two high P.C.E. brick exemplifies the joint erosion common to such brick. It should be observed, however, that the total erosion of the cone 31 brick at an equal number of heats is about 100% less than that of the cone 16 brick. It may also be inferred that, if the rate of joint erosion of the cone 31 brick does not increase, a lining of this brick, barring skull formation, would last three or four more heats than the cone 16 brick.

Figures 7, 8, 9, 10, and 11 exhibit other aspects of cracking, spalling, joint erosions, and steel fins in joints encountered during the experimental tests of high P.C.E. brick in steel ladles.

(1) Ladle-Lining Costs

Ladle-lining costs per ton of ingots, including labor, vary considerably because of different conditions of use. These costs do not reflect losses or gains associated with steel

FIG. 9.—High and low P.C.E. brick from same ladle: *left*, P.C.E. 32, alumina 38%, porosity 20%; *right*, P.C.E. 17, alumina 25%, porosity 20%.

qualities, which, it may be argued, are affected by the different quantities of fire clay or fireclay derivatives imbedded in the solidified steel.

Because the erosion of brick at the bottom of the ladle and about 25% of the side lining upward therefrom determines ladle service life and constitutes about 65% of the total ladle brick erosion, improvements may be appraised either in terms of cost per ton of ingots or by assuming

that any nominal excess cost will be offset by lower steel conditioning expense.

The cost per ton of ingots for a complete low P.C.E. brick lining is about $0.09. A composite lining (50% high P.C.E. brick in the lower part of the ladle and 50% low

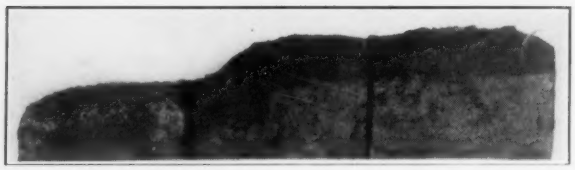

FIG. 10.—Low P.C.E. and 60% alumina brick from same ladle: *left*, P.C.E. 17, alumina 25%, porosity 20%; *right*, P.C.E. 37–38, alumina 60%, porosity 30%.

P.C.E. brick in the upper) will cost about 27% more than an entire low P.C.E. brick lining. To attain equal costs, the composite lining must outlast the low P.C.E. lining by four heats.

This parity of costs does not seem difficult to attain, provided the high P.C.E. brick are not prematurely destroyed by the occurrence of ladle skulls. If only an equal

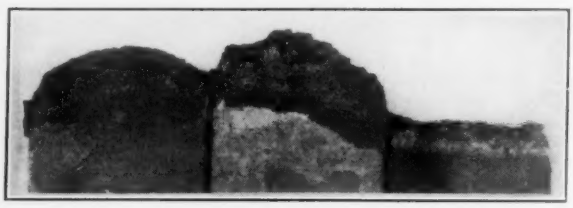

FIG. 11.—Low P.C.E. and 70% alumina brick from same ladle: *left*, P.C.E. 38, alumina 70%, porosity 34%; *right*, P.C.E. 17, alumina 25%, porosity 20%.

number of heats should follow the use of the composite lining, the cost per ton of ingots would be increased by about $0.024, an excess which might be entirely offset by decreased conditioning costs.

In common with other workers, the writer has attempted to develop simulative laboratory slagging tests and have discovered that the results of these are questionable measures of service results.

The current method of testing ladle brick, which is much nearer the mark of practical service appraisal, is as follows: A panel of 12 or 15 of the brick to be compared with the standard lining is laid in a ladle otherwise lined with the standard ladle brick. This panel is so situated in the ladle lining that it is subjected to erosion which is intermediate between minimum top and maximum bottom erosion. Observations of this panel during the life of the lining give a progressive measure of the relative characteristics of the standard and test brick, and when the ladle is removed from service the test brick can be recovered, measured, and otherwise compared with the standard lining.

Panels of brick which give promise of improvement over the standard lining are further appraised by lining a ladle with two complete vertical half sections, one of the standard brick and the other of test brick.

VI. Conclusions

Inclusions in solidified steel vary in frequency of occurrence, in distribution, and in characteristics. Although these complex conditions cause the origins of many types to be uncertain, probably all are dominantly related (1) to steel melting and deoxidation, (2) to the subsequent tapping of the molten steel through fireclay-lined spouts into ladles so lined, and (3) to pouring through fireclay wells and nozzle brick.

The probability of inclusion occurrences, attributable to the melting and deoxidation phases of steel production, has been decreased markedly because technologic metallurgy has made possible the practical use of improved and systematized procedures.

Similar procedures have not been followed in connection with steel pouring refractories, and, until comprehensive studies of these are undertaken coöperatively by ceramic and metallurgical technologists, no perceivable order of improvement in the existing status of the inclusion problem can be expected.

Acknowledgment

The author wishes to acknowledge his indebtedness to W. S. Debenham and W. R. McLain, without whose interest and assistance this memoir would have been less complete.

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SUGGESTED INSULATING FIREBRICK SPECIFICATIONS*

By W. Raymond Kerr

I. Introduction

Although insulating fire brick are relatively new, rapid strides have been made in their application. During the past ten years, in many instances, applications have outdistanced the formation of any set of specifications, principally because many of the new types of installations have been of an experimental nature.

In drawing up a set of specifications for insulating fire brick for any particular application, one can not be too familiar with the differences that exist between insulating firebrick and fireclay refractories when comparing similar properties. Apparently the more highly porous insulating fire brick are more "sensitive" to physical changes than are the denser materials. This greater "sensitivity" should be carefully considered in the preparation of all specifications.

The choice of the word "sensitive" may not be a fortunate one. It does not necessarily mean that the brick are to be classified as inferior in any way. Rather, it means that, owing to their intrinsic properties, the insulating fire brick react to a greater degree in test procedures. For given temperatures, the shrinkage of a very lightweight brick is generally greater than for a denser refractory of the same material. Plastic flow under load at high temperatures is more pronounced. Permeability is greater. All of these differences, when integrated, cause the insulating fire brick to possess this so-called "sensitivity."

There have already been many specifications issued both by the producer and the consumer on the subject of insulating fire brick. These have included practically all types of service, ranging from installations where the insulating fire brick have been used to back up a refractory wall to installations in which the product has been directly exposed to the flame in high-temperature furnaces.

A specification, broadly speaking, is drawn up to insure that certain properties of material be adhered to. Primarily, it protects the customer; secondarily, it is a spur to the producer to improve the commodity to which the specification applies.

Specifications, to be of value, must include tests that can be conducted by separate operators in different laboratories and that yield comparable data. The specification must contain test methods that evaluate specific properties and it should also detect differences among the various brands being tested. If the test does not classify different types of material properly into relative groups as to service, it has a questionable value and should not be included.

There are a number of physical and chemical properties commonly associated with insulating fire brick. The value of these properties for inclusion in the specifications will be discussed, but the order in which they are taken up is not necessarily the order of their relative importance.

II. Chemical Composition

Chemical composition is unimportant in most cases, provided the other properties of the brick enable it to withstand working conditions in any particular type of furnace. There are certain chemical aspects, however, that should be kept in mind in the formulation of specifications.

Where strongly reducing conditions are maintained, a specified low iron content is advisable. This would likely be a figure under 2% of Fe_2O_3. In general, the experimental data show that insulating fire brick as a class are not so subject to disintegration under reducing conditions as are denser refractories. This is attributed by the writer to the larger pore size of the insulating fire brick whereby the carbon granule, deposited from CO atmospheres, may have much more room to grow before it finally exerts sufficient pressure to crack the brick structure. Another factor that retards disintegration of the lightweight brick is the fact that its permeability is usually higher than that of a dense brick, and a sufficient amount of oxygen is admitted to partly burn the carbon deposited within the brick. Because iron is generally accepted to be one of the causes of carbon formation, this particular component should be kept at a low figure.

There are several points in connection with high silica content that require some treatment. The first of these is the opinion that a high silica content is necessary for low conductivity. This is not at all true, and therefore a specification based on one particular chemical component, such as silica, is certainly not scientifically prepared.

Siliceous insulating fire brick tend to spall somewhat more than fireclay insulating brick originally fired at the same temperatures. There are, however, a number of marked exceptions to this general rule. The silica content therefore can not be considered to be the deciding factor in the chemical constitution of insulating fire brick.

There has been a tendency to emphasize the advantage of alumina in an insulating fire brick. The idea has even been advanced that a brick with a high alumina content has less tendency to spall. This has not been observed in actual practice, and it is believed to be of dubious value to include any reference to alumina in the specification.

This appears to be an indefinite attitude to take regarding the chemical make-up of an insulating fire brick. From their general behavior under actual working conditions, however, it must be judged that there are many factors, in addition to chemical composition, contributing to the picture. The iron content ordinarily should be kept low when the brick are to be used under reducing conditions, and the amount of fluxes should be kept as low as possible so that the brick will not have a tendency to fail in service because of an undue lowering of refractoriness.

III. Pyrometric Cone Equivalent

The P.C.E. usually is no indication of the useful range of an insulating fire brick. It merely serves as a guide to the refractoriness of the product. In considering specifications for insulating fire brick, special note should be

* Presented at the Annual Meeting, Ohio Ceramic Industries Association, Columbus, Ohio, October 7, 1938. Received November 22, 1938.

made of the fact that the material is usually much less dense than firebrick refractories and that this lightness of weight causes them to react differently than fire brick in most tests.

For example, let us consider a fire brick with a density of 120 lb. per cu. ft. and a fireclay insulating fire brick with a density of 60 lb. per cu. ft. Furthermore, let us consider that these two products have been made from the same clay body with a P.C.E. of cone 32 and each product has been fired in a kiln to the same temperature, 2400°F. A P.C.E. test on each product will show cone 32 without any apparent difference, but the denser fire brick will be usable at a much higher temperature than the insulating fire brick because of its greater density, and it will react less to a load test or reheat-shrinkage test.

This statement in no wise condemns insulating fire brick as a group. It is given to confirm the statement made in the introduction that the light-density material is sensitive to a greater degree than fire brick. The temperature at which insulating fire brick are originally fired is a determining factor of the temperature at which they can be used. It is furthermore a factor of probably greater importance in insulating fire brick than it is in fire brick as far as usable temperature limits are concerned. Because the actual P.C.E. of any particular lightweight brick is usually so greatly in excess of the firing temperature as to bear no direct relationship to it, it is not judged to be of sufficient importance to include the P.C.E. in specifications. The greatest value of a P.C.E. test, in the case of insulating fire brick, is as a factor of safety but not as a guide to the useful temperature range of any particular brand.

IV. Density (Bulk Specific Gravity)

The factor of bulk density is important from several angles and should be included in all specifications. A saving in weight usually can be associated with the design of a furnace and will result in possible savings on the steel construction. Lightness in weight furthermore is important in designing movable hood-type covers.

The specific heats of various clay insulating fire brick are similar, if not identical. This being so, the brick of low bulk density have lower heat capacity and therefore show a greater saving in fuel than brick of greater bulk density. In addition to this, the lower heat storage permits greater flexibility in heating and cooling. As a result, more heats may usually be obtained per furnace day with the lighter weight brick.

Lower bulk density for any given brick almost invariably means lower conductivity. This is not to be construed as a statement that the lightest weight brick is the best insulator, but in a general sense this statement is true. It is therefore believed to be proper to include a figure for bulk density in any specification because it is a direct protection to the customer. The exact figure, of course, will depend upon the application of the brick.

It might be well also to classify the bulk density according to the use to which the insulating fire brick is to be put. If it is to be used to back up a refractory, the density should be relatively low, approximately 30 to 35 lb. per cu. ft. For light-duty service in the average industrial furnace, there is a considerable range of density permissible, depending on constructional features. In general, these furnaces would employ insulating fire brick with densities of 35 to 50 lb. per cu. ft. The third classification includes furnaces operated under relatively abusive conditions, and it would be permissible to include the higher density range of approximately 45 to 65 lb. per cu. ft. It will be difficult to lay down any definite rules for the exact bulk density limits because every type of furnace presents its own individual problems of construction.

V. Dimensions

The inclusion of dimensions as a physical property may be questioned. A great many installations of insulating fire brick are laid dry and therefore accuracy in sizing is essential. Thin joints are usually recommended for insulating fire brick because such joints are associated with low heat losses.

Present-day sizing methods used in the production of insulating fire brick in general are accurate, and there is little reason for a customer to accept brick that are not extremely close to size. It is believed that a specification holding all dimensions to a $\pm 1/32$-in. tolerance is not unreasonable, inasmuch as all manufacturers appear to realize the importance of accuracy in finishing to standard dimensions.

VI. Porosity

Porosity varies almost directly with the bulk density, but pore size is almost as important as the percentage of porosity on account of the effect of pore size and shape on such properties as strength, shrinkage, conductivity, etc. Most manufacturers select a pore size that will produce a brick of uniform texture and relatively smooth appearance. The porosity, expressed in percentage of total volume, can not be carried to an unusually high figure because as porosity increases, the strength decreases. Here again, as in pore size, the manufacturer has selected a figure for porosity that agrees best with the other properties and permits sufficient strength and uniform appearance.

Because a number of other properties effectively limit the permissible pore size in insulating fire brick and also determine the percentage porosity permissible in any particular brick, neither porosity nor pore size need be considered for inclusion in specifications, particularly if bulk density has been considered and made a part of the specification.

VII. Permeability

In the field of refractories, permeability receives more attention than does porosity as a property of insulating fire brick, in which it is usually much more pronounced than in the denser refractory brick. In the average installation of insulating fire brick, however, permeability is probably important only where it can not be corrected or minimized.

Permeability can be minimized in several ways. The first of these is to use a tight steel shell construction, which retards air infiltration through the brick, particularly when the furnace is operated on draft. Another method to reduce permeability is by means of a coating or facing on the inside of the furnace lining. This will reduce the

air infiltration approximately 50%. Usually this facing consists of two coatings, of eggshell thinness, of a refractory air-set cement.

Permeability in very porous products is a property that is difficult to control, and it is believed that it should be included in specifications only when it can not be compensated for or minimized by the foregoing methods in any given type of construction.

VIII. Compressive and Cold Crushing Strengths

Modern constructions of insulating fire brick make few demands upon the compressive strength, except where unusual thrusts may occur, *e.g.*, in expansion that is not provided for; 10 lb. per sq. in. is probably extremely high for many side-wall constructions. Arches are sometimes required to withstand higher loads than this, especially during the heating-up period when a side thrust is exerted owing to the expansion of the brick. The load on the brick in an arch probably is rarely more than 50 lb. per sq. in. Practically any brick on the market will withstand this compressive load without failure.

On the other hand, compressive strength is a good yardstick to measure how well insulating fire brick can be transported in shipment. A general statement may be made that a compressive strength of less than 150 to 175 lb. per sq. in. is undesirable from the standpoint of shipment. A minimum specification figure near this range, therefore, would probably assure the customer of receiving shipments without breakage.

IX. Modulus of Rupture (Transverse Strength)

Modulus of rupture is rarely important except where a single span is concerned or where a wall tie-in is involved. In any event, it is probably of doubtful value because it is a figure that falls off in most insulating fire brick with repeated heating and cooling. Usually, this factor would be more valuable if it were known for the brick in a heated condition, but this figure is difficult to determine without special apparatus and it is complicated at the higher temperatures by the additional factor of plastic flow.

Modulus of rupture therefore is of doubtful value, except as a measure of the original cold strength of the brick. The compressive strength is preferred as a measure of strength because it is more easily determined.

X. Thermal Conductivity

Thermal conductivity is a property in which the customer is definitely interested, and it should be included in all specifications. It should perhaps be broken down into several separate classes because furnaces can be considered under more than one broad classification.

There are many so-called "backup" installations where the insulating value is extremely important. These include electric furnaces in which the customer is interested in saving all the current possible. It is not unusual in such an installation to have several inches of diatomite powder on the outside and at least 9 in. of "backup" brick with an insulating firebrick lining sometimes exceeding 9 inches in thickness. A figure of under 2 B.t.u. at 1500°F mean temperature for the commercial conductivity of the "backup" material is suggested for this application.

There are the many ordinary types of insulating firebrick applications usually found in heat-treating practice. Here fuel-saving is important, but it must be balanced by other factors, such as spalling resistance and general flexibility. Under these conditions, it would be recommended that the commercial conductivity be kept under 3 B.t.u. at 1500°F mean temperature.

There are, broadly speaking, a considerable number of installations where fuel saving is not the only consideration, but where a furnace is needed that will take considerable punishment and yet be light in weight and have a high degree of flexibility. For this type of installation, the brick are usually directly exposed. A commercial conductivity of about 3.5 to 4 B.t.u. at 1500° mean temperature is necessary for this type of application at the present time.

Any discussion of thermal conductivity would be incomplete without a reference to the methods used to determine this property. For a number of years the methods of measurement have been the subject of investigation by several different groups of investigators. A comprehensive study of a number of methods for determining the conductivity of refractories was reported at a symposium on thermal conductivity at the Annual Meeting of the American Ceramic Society in February, 1934. The results have been published and confirm the fact that different test procedures yield different results.* At the present time, another investigation is under way among several coöperating laboratories with samples from identical high-temperature block insulating materials. It is hoped that out of this work may come a standardized procedure for determining thermal conductivity at high temperatures in an accurate manner.

Because of the difficulties involved in the determination of thermal conductivity and because of different results liable to be obtained with different types of apparatus, the method decided upon for specification tests should be explicitly stated.

XI. Hot Load Tests

Before beginning a discussion of hot load tests, it should be mentioned that data for the hot load-bearing ability of practically all types of insulating fire brick can be shown as a curve in which the load-bearing ability is plotted against the temperature. As the temperature rises, the load-bearing ability also rises until a point is reached at which plastic flow starts; then the strength tapers off,

* Among the papers from this Symposium, the following were published: (1) C. E. Weinland, "Measuring Thermal Conductivity at Furnace Temperatures," *Jour. Amer. Ceram. Soc.*, **17** [7] 194–202 (1934); (2) H. W. Russell, "Principles of Heat Flow in Porous Insulators," *ibid.*, **18** [1] 1–5 (1935); (3) J. L. Finck, "Apparatus for Measuring Thermal Conductivity of Refractories at High Temperatures," *ibid.*, **18** [1] 6–12 (1935); (4) W. M. Hepburn, "Insulating Refractories," *ibid.*, **18** [1] 13–17 (1935); (5) W. C. Rueckel, "Physical Properties of Some Insulating Brick," *ibid.*, **18** [1] 18–22 (1935); (6) R. H. Heilman and R. S. Bradley, "Thermal Conductivity of Refractories under Operating Conditions," *ibid.*, **18** [2] 43–48 (1935); (7) J. B. Austin and R. H. H. Pierce, Jr., "Reliability of Measurements of Thermal Conductivity of Refractory Brick," *ibid.*, **18** [2] 48–54 (1935); and (8) L. B. Miller, "Effect of Insulation on Silica Refractories of an Open-Hearth Steel Furnace Roof," *Bull. Amer. Ceram. Soc.*, **14** [11] 359–64 (1935).

and as plastic flow becomes more apparent, the brick slumps. Insulating fire brick have been tested in which the cold strength is doubled when the temperature is raised as high as 1600° to 1800°F.

Articles have been published on the subject of hot load tests on insulating fire brick, but the tests have not yet been sufficiently developed to a point where they show any definite property to be interpreted in terms of service.

Panel-type tests have been compared to load tests under soaking heat conditions. In the panel test, the load service is simulated, but usually no data of value are obtained because of the temperature gradient through the panel. This temperature gradient should be strongly stressed because, in the average wall of insulating fire brick, the gradient is so great that the center portion of the wall can always support the entire weight. The panel-type hot load test therefore will usually show little or no subsidence.

In a load test in which the brick is completely surrounded by soaking heat conditions and subject to rising temperature, a point is reached at which plastic flow starts. Such tests do not simulate furnace conditions except for piers, and in such cases a stronger brick than insulating fire brick should be used unless the service temperature is on the upward slope of the curve for temperature *vs.* load-bearing ability.

The point should be stressed very strongly that practically no failures of insulating fire brick due to load have occurred under working conditions. There have been spalling of arches, bulging of side walls due to insufficient expansion joints, and fusion due to too high a temperature, but insulating firebrick failure under load has been extremely rare. This is attributed to the rather steep thermal gradient that usually occurs in an insulating firebrick wall.

Although the hot load test is perhaps desirable in special cases, it is not sufficiently well developed at the present time to be included in specifications for insulating fire brick.

XII. Spalling

Although spalling is a property frequently inquired about, at the present time there is no standard test for its determination. There have been several publications on the subject, but no particular test has yet been adopted as standard.

Some experience should have been gained by this time regarding the adoption of various spalling tests for refractories, and it is believed that caution should be used in the adoption of a spalling test for insulating fire brick. It would not be desirable to adopt any test that does not approach service conditions. Examples of such tests would be (1) to heat a brick in a furnace and plunge it in water or (2) to heat it in a furnace and cool it on the floor. The writer has seen such tests used to evaluate insulating fire brick.

The panel-type test is believed to offer the best solution to the question, but if the A.S.T.M. type is used, it should probably have several modifications. It certainly would be desirable to have a less rapid cooling rate than the A.S.T.M. test. The entire problem of panel-spalling tests in connection with insulating fire brick is complicated by the extremely rapid rate at which they lose heat when compared to fire brick. This loss is caused by the low heat-storage capacity of insulating fire brick as compared to fire brick. Although no recommendation can be made now, a suggestion should be made that a satisfactory spalling test for insulating fire brick would be heartily welcomed; however, until an agreement is reached among the various interested laboratories, no definite recommendation can be made.

XIII. Reheat Shrinkage

The question of reheat shrinkage is one that can become controversial at the present time because of tests already existent in the A.S.T.M. Manual and because panel-shrinkage tests have been made and presented on various types of insulating fire brick. The latter tests are still in process of being confirmed by other laboratories and may ultimately serve as the basis for an entirely new type of test for shrinkage.

Freedom from shrinkage in service at any specified temperature is important and some limit should be placed on the brick. The function of time, however, on the shrinkage of the "sensitive" insulating fire brick is decidedly important. No short-period tests therefore should be used, because this would show some brick to an unfair advantage that they might not show if the tests were prolonged to simulate conditions in actual service.

Because atmospheric control is common with insulating firebrick installations, tests might be made at some future date for insulating fire brick under special atmospheric conditions. These tests of necessity would be special for special specifications, based on the fact that certain atmospheres induce more shrinkage than do oxidizing conditions. This statement has been pointed out in previous publications.

The present A.S.T.M. C93–34T test for shrinkage is fairly severe. Experience has shown that "soaking" conditions produce more apparent shrinkage than when brick are tested in a panel-type test. Therefore, when the A.S.T.M. test is used, the tolerance for a specification should perhaps be 2 to $2^1/_2\%$ linear shrinkage at any predetermined temperature, and in the panel-type test, it should perhaps be as low as $^1/_2\%$. More experience will have to be gained on the panel-type test before a definite recommendation can be made.

XIV. Summary

The points discussed are the most important of those in which both producer and consumer are interested. It is difficult to discuss such a large number of properties in so short a space without omitting references to numerous essential data. This fact should be borne in mind if some of the statements appear to be dogmatic. It is hoped that certain essential points have been covered and that they will serve as a basis for further discussion and as a guide in the preparation of specifications for insulating fire brick on a more sensible and scientific basis.

Armstrong Cork Company
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IMPROVED MACHINE SHOWS DIFFERENT FORMS OF FAILURE OF CLAY BODIES IN TORSION*

By Robert P. Graham and John D. Sullivan

Abstract

An improved torsion apparatus for studying the workability of clays is described in detail. The study showed that the initial failure of solid clay bars in torsion occurs in lines approximately parallel to the axis of the bars, if the clays are plastic or slake to fine particles on addition of water, and perpendicular to the axis for nonplastic and non-slaking clays. Ultimate failure in both cases is approximately perpendicular to the axis. Initial failure of the bar also occurs simultaneously with the maximum torque transmitted by the bar.

I. Introduction

This paper is the second in a series on a general study of base-exchange phenomena in clays. The first paper[1] outlined methods for analyzing exchangeable bases in clays and similar argillaceous materials.

During the past decade much work has been done on studying plasticity, workability, and other mechanical properties of clay bodies, but unfortunately the tools necessary to make the measurements are not standardized, and interpretation of the results obtained has lacked uniformity. Wilson[2] described a torsion machine for testing clays which showed considerable promise, but failure of the specimens often occurred at the holding chucks, thus hampering the reproducibility of the results. Norton[3] used a tubular specimen and was able to overcome this difficulty, although the use of a tube added additional difficulties when working with very soft bodies.

The authors believe that the torsion machine has greater possibilities than any other laboratory method so far used. It is, however, still in the development stage; so improvements made on it during the present investigation are reported. The aim was for simplicity and reproducibility. The improved machine detected, what was not heretofore recognized, that there are two distinct types of failures of bars in torsion. These types of failures are discussed in detail.

II. Preparation of Specimens for Torsion Machine Tests

The bars for the torsion tests were $1/2$ inch in diameter, extruded with a de-airing machine at $28^1/_2$ to 29 in. vacuum. The extrusion machine, shown in Fig. 1, consisted of a 3-in. brass cylinder fitted with a mechanically driven ram. The cylinder was filled with shredded clay, and the air was removed by a vacuum pump. The vacuum connections to the extrusion cylinder were made through a hole behind the extrusion ram and through a rubber tube placed in the mouth of the extrusion die. The latter connection was forced out by the clay column at the start of extrusion. Evacuation from both ends of the extrusion cylinder was necessary to get reproducible results in tests on bars.

The die consisted of a $1/2$-in. thick cylinder cap with a $1/2$-in. hole reamed in the center thereof. The inside $3/8$ in. thickness of the cap was reamed with a 0.6-in. per ft. taper reamer. Several variations, including the reduction of the diameter of the extrusion cylinder, both with and without changing the speed of the ram, and the insertion of a 45-degree brass forcing cone in the end, were tried, but the results were not affected appreciably. The changes had virtually no effect on the yield point or maximum torque but effected a slight reduction in the angle at maximum torque; the relationship between the water content and the angle at maximum torque, however, still held, *viz.*, that the angle at maximum torque was virtually constant with changing water content in the stiff-mud working range.

III. Specimen Holders

In order to hold the specimens in the torsion machine, the ends were forced into hollow brass sleeves which, in turn, were gripped in the machine. Figure 2 (*A*) shows the assembled specimen; (*B*), the gripping sleeves; and (*C*), the mold used to shape the bar. (*B*) consisted of two pieces of $1/32$-in. wall telescopic brass tubing, $1/2$ and $9/16$ in. square, inside, respectively. One end of the smaller piece was recessed about $1/4$ in. inside the larger sleeve, while the other end of both sleeves was flush, and the two pieces were sweated together. The assembled gripping sleeve was $3/4$ in. long. Because the inside sleeve was $1/2$ in. square at the outer end and $9/16$ in. square at the end toward the center of the specimen, it just slid over the $1/2$-in. clay test bar and thus centered it automatically. The cavity of the split brass mold, Fig. 2 (*C*), was reamed to $1/2$-in. diameter and had recessed corners to permit the formation of fillets on the bar. The halves of the brass mold were lightly oiled and placed together over the bar. The gripping sleeves were slid into place and the mold was clamped. The ends of the specimens were formed in the mold (*C*) by a small hand press, shown in Fig. 3. This type of press left the mold free to move and, therefore, applied the same load to each end of the specimen and forced the clay into the corners and fillets. The use of the press materially decreased the time required to prepare the specimen and also prevented the possibility of distorting the center of the bar

* Scheduled for the Forty-First Annual Meeting, American Ceramic Society, Chicago, Illinois, April 19, 1938 (Structural Clay Products Division). Received January 5, 1939. Work done under Battelle Research Associate Fund.

[1] R. P. Graham and J. D. Sullivan "Critical Study of Fund. Methods of Determining Exchangeable Bases in Clays," *Jour. Amer. Ceram. Soc.*, **21** [5] 176–83 (1938).

[2] E. O. Wilson, "Plasticity of Finely Ground Minerals with Water," *ibid.*, **19** [4] 116–20 (1936).

[3] F. H. Norton, "An Instrument for Measuring Workability of Clays," *ibid.*, **21** [1] 33–36 (1938).

by uneven pressing. Experiments showed that the pressure required to form the ends of the specimen was not sufficient to cause any changes in the results of the torsion tests. The force reaching the center of the specimen was

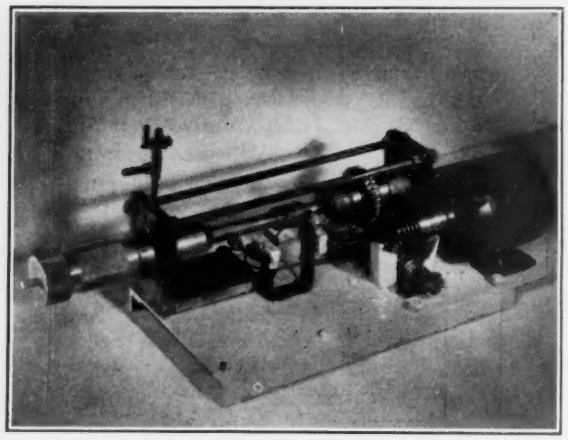


FIG. 1.—De-airing extrusion machine.

probably less than that applied to the bar during extrusion. Failure of the bar at the chucks during the torsion test was not encountered with specimens made in the manner described.

IV. Torsion Machine

The torsion machine shown in Fig. 4 consisted primarily of a motor-driven chuck turning at 3 revolutions per minute, which applied a torque to one end of the bar, and a spring-loading device that resisted and measured the

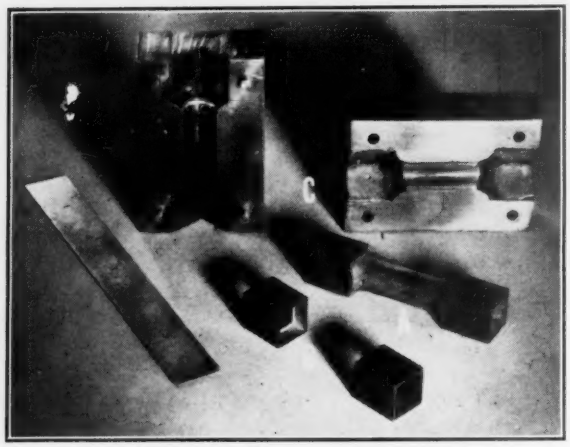


FIG. 2.—Specimen and assembling equipment.

torque transmitted through the bar. A continuous curve of the torque *vs.* the angular deformation was drawn by a stylus on a smoked-glass plate. The curve on the smoked plate was enlarged by projection onto a calibrated chart.

The oil damper on the left side of the balance beam was a critical part of the torsion machine and was necessary to bring out the yield point distinctly and to damp out vibrations of the loading beam caused by sudden changes in the rate of loading the clay bar. The damper consisted of a piece of aluminum, $^1/_{32}$ in. thick and of about 10-sq. in. area, immersed in mineral oil. To determine the proper viscosity of oil, the machine was first operated without any oil in the damper chamber and then with a mineral oil more viscous than desirable. The heavy oil was diluted with lighter mineral oil until the damper showed no loading effect in the results on clay bars.

V. Calibration of Machine

The machine was calibrated by suspending weights at the end of the balance arm. By using a combination of weights, a complete set of concentric lines, representing known torques, was drawn on a smoked-glass plate. The plate was also ruled at definite angles to give the skeleton

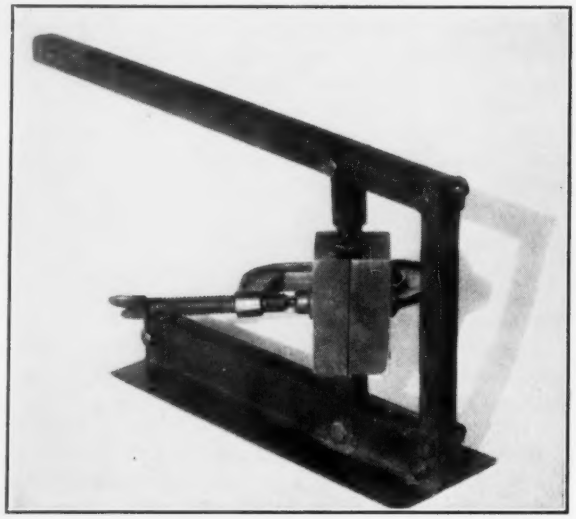


FIG. 3.—Hand press for forming ends of specimen.

of a calibration chart. This chart was enlarged by projection, and the radii of curvature and centers of the grid line were measured graphically at the enlarged scale. This information was used to construct a final master calibration chart from which copies similar to the one shown in Fig. 7 were made. Since the smoked plate was operated by a flexible steel ribbon turning on a segment of a circle and since the calibration chart as constructed corrected automatically for the change in angle of twist caused by the displacement of the beam, converting to rectangular coördinates or making further corrections was unnecessary. The machine was checked for agreement with the chart at frequent intervals, and any necessary corrections were made by adjusting the tension of the springs.

VI. Data from Torsion Tests

Torsion tests gave the yield point, the maximum torque, the angle at which maximum torque occurred, and the angle of ultimate failure. In the case of plastic clays, the precision of measurement of yield point and maximum torque was about $\pm^1/_2\%$ for bodies falling in the middle of the working range of the machine and about $\pm 2\%$ for bodies of low yield point and low maximum torque. In

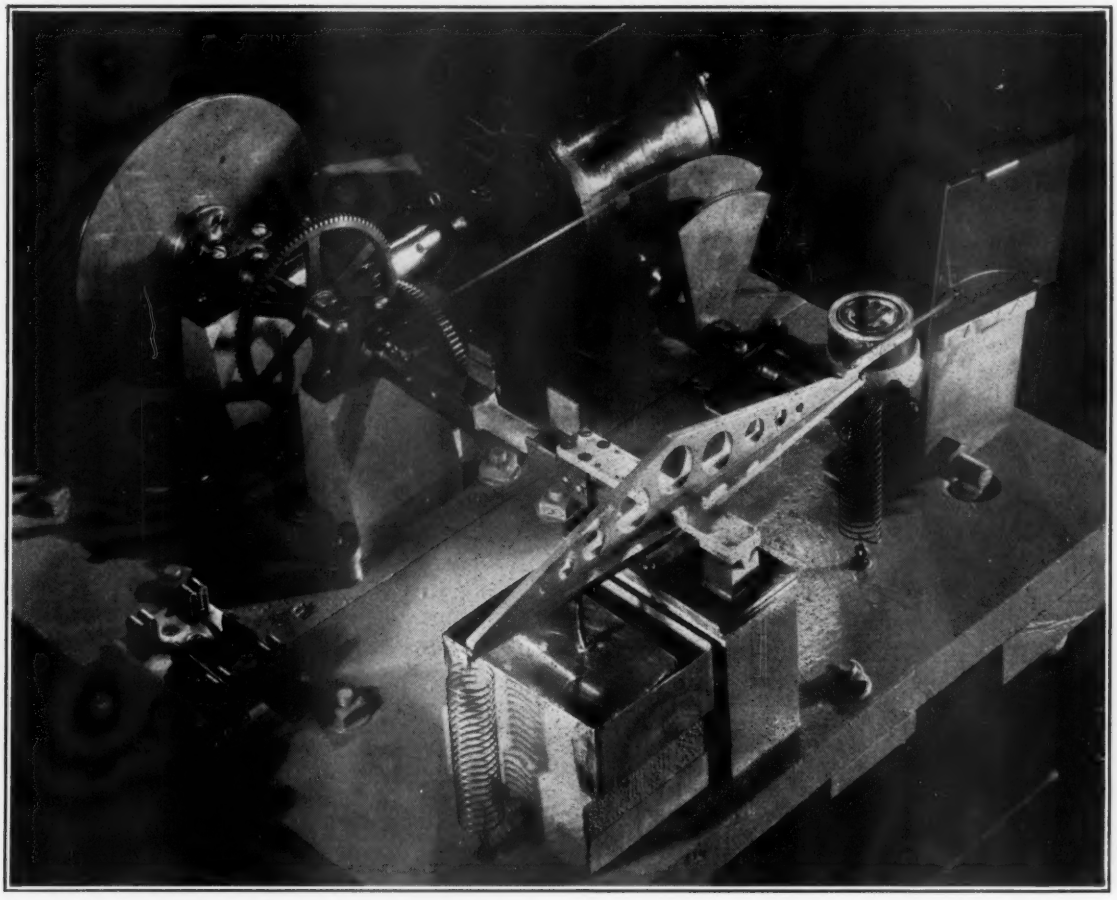


FIG. 4.—Torsion testing machine.

the case of nonplastic materials, the variation was somewhat greater and depended on particle size. The maximum deviation in the angle at maximum torque of plastic bodies was about ±3 degrees, but in most cases it was much less.

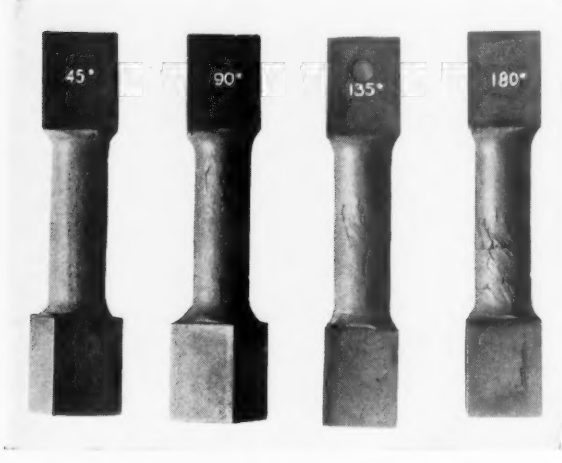


FIG. 5.—Plastic clay specimens at different angles of twist.

VII. Preparation of Clay for Torsion Tests

The clay body was made up to the desired water content approximately 24 hours before testing to obtain even moisture distribution throughout the clay mass. The body was mixed by running it through a small meat grinder, worked into a ball, and then placed in a container having a water-saturated atmosphere. After 24 hours, the body was again run through the meat grinder to shred it for de-airing. The de-aired clay was extruded from the machine and cut in $3^1/_4$-in. lengths. The bars were numbered as they came out of the extrusion machine; Nos. 1 and 8 were used for moisture determinations, and Nos. 2 to 7, inclusive, were run in the torsion machine. The bars, as they came from the extrusion machine, were placed in a container having a water-saturated atmosphere. Tests were completed within one-half hour after extrusion.

VIII. Form of Failure with Different Types of Clays

The literature makes no distinction in the form of failure of bars made from different types of clays. In this investigation, the discovery was made that there are two distinct forms of failure. The first, characteristic of plastic materials or those that readily slake to fine parti-

cles, occurred on lines parallel to the axis of the bar; the second, characteristic of materials that do not slake to fine particles, occurred approximately at right angles to the axis.

When a bar commences to fail, the torque it will transmit simultaneously starts to drop. The curves of Fig. 7 pass through a maximum, and the angle at which the maximum occurs coincides with initial failure of the bar. The angle at which maximum torque occurs, in the case of the first type of bodies, does not coincide with the angle of ultimate failure. In the case of the second type of bodies, the two angles virtually coincide. Actually, even in the first type of bodies, the ultimate failure is at approximately right angles to the axis. Extremely dry bodies of either class tend to fail as second-type bodies, and there is also a tendency for failure to occur at an angle of about 45 degrees or slightly higher.

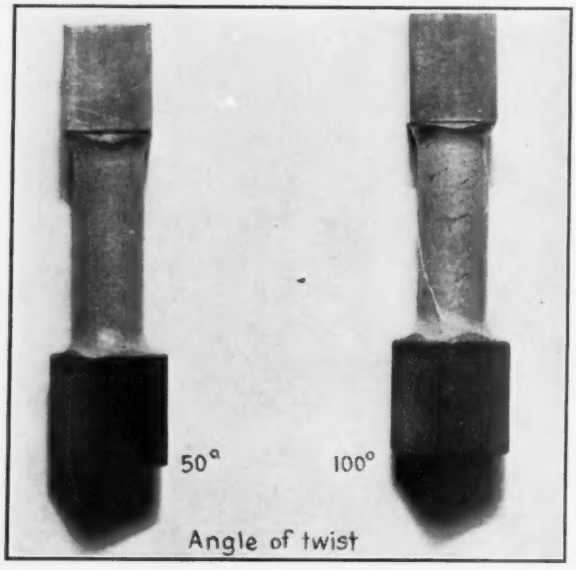


FIG. 6.—Nonplastic clay specimens at different angles of twist.

Figure 5 shows four bars of a given plastic clay that were twisted to various angles in the torsion machine. The first, twisted 45 degrees, shows no fracture; the next, twisted 90 degrees or to a slightly greater angle than the one at which initial failure occurred, has longitudinal slits in the surface; the third, twisted 135 degrees, exhibits further longitudinal fracture; and the fourth at 180 degrees has a complete fracture across the axis. When the torque is released, before ultimate failure, the bars tend to return to their initial position. This may be observed in the photograph, as the deformation appears to be less than the actual angle of twist. Figure 7, in which the stress-strain curve of this body is included, shows that the angle of maximum torque occurred at about 68 degrees.

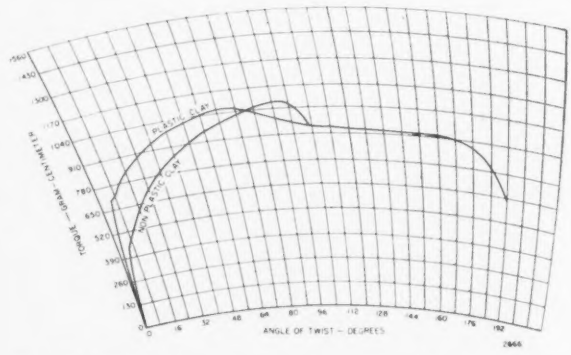


FIG. 7.—Typical torsion machine curves showing forms of failure of different types of clay.

The two nonplastic specimens in Fig. 6 were twisted to angles before and after failure occurred. Fracture occurred across the axis without any longitudinal fractures.

Figure 7 gives the complete torque *vs.* angle-of-twist curve for the specimens of Figs. 5 and 6. The plastic clay was a Kentucky ball clay and the nonplastic, a Kentucky flint clay.

Papers on data obtained in torsion and other tests are in preparation.

BATTELLE MEMORIAL INSTITUTE
COLUMBUS, OHIO

FORTY-FIRST ANNUAL MEETING, AMERICAN CERAMIC SOCIETY

Hotel Stevens, Chicago, Ill., April 16–22, 1939

The various local committees in Chicago, in charge of affairs for the Forty-First Annual Meeting, have been active in preparation of plans and details for a record attendance of members of the American Ceramic Society.

Orton Memorial Lecture

The first major activity for the Meeting will be the Orton Memorial Lecture scheduled for the Grand Ballroom on Sunday evening, April 16, at 8:00 P.M., with L. E. Barringer as the lecturer for 1939. Mr. Barringer's subject is "A Background for Ceramics."

The Entertainment Committee has planned a musical program for Sunday with a singing-playing musical combination and a four-piece orchestra.

Monday Evening Open House

On Monday evening, a Bavarian type of entertainment is planned, holding Open House, serving beer and sandwiches, and with music by a German band. Singers and other entertainers will be included on the program.

Student-Alumni Dinners are to be held Monday evening, from 7:00 to 9:00 P.M, at places to be chosen by the various college representatives. The Student Reception will follow at 9:00 P.M. in the Boulevard Room, Hotel Stevens.

Tuesday Evening Dinner-Dance

Tuesday evening has been set aside for the usual dinner-dance. From 7:00 to 9:00 P.M., a special orchestra will furnish music during dinner, and singing and playing strollers will be present.

From 9:00 P.M. to 1:00 A.M., a 10-piece orchestra will furnish music for dancing.

Admission will be $2.50 per plate, tax included.

Wednesday Evening Tribune Tour

The Entertainment Committee reports that Wednesday is to be an open night, but for those who would like to make the tour, arrangements have been made for a group to visit the color press departments of *The Chicago Tribune*. This tour is to be followed by attendance at a broadcast from the studios of WGN. Reservations for the broadcast have been limited to 250 persons.

Women's Entertainment

For the entertainment of the women attending the Annual Meeting, Wednesday has been set aside for a tour of the world-famous department store, Marshall Field & Co., beginning at 10:00 A.M.

The tour will be followed by a bridge luncheon, a talk and demonstration on table settings, and a style show.

Part of the expense for this day at Field's will be borne by the Entertainment Committee, although some small payment will be made by those who attend.

The Program Outline Schedule (p. 61, February *Bulletin*) carries complete details of the Division and committee meeting rooms.

The members of the Entertainment Committee are R. A. Beverley, *Chairman;* Fred Buck, Bart Fennessy, C. L. Frederick, Jr., Richard Goble, H. J. Shaner, Bruce Wagner, D. B. Walters, and E. W. Woodruff.

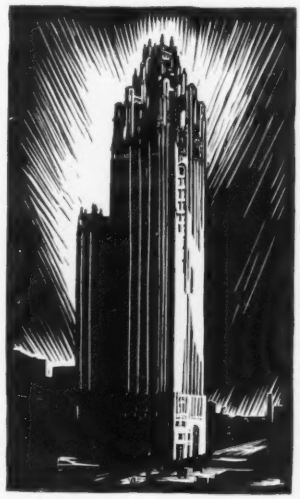
SOCIETY MEMBERS INVITED TO THE CHICAGO TRIBUNE TOWER

Tour and Broadcast

An "extra-curricular" number during the Forty-First Annual Meeting in Chicago, Ill., has been planned for Wednesday evening, April 19.

One of the largest and most modern newsprint plants in the world, *The Chicago Tribune*, with a daily capacity of over a million standard-size copies, will be shown to a limited number of visitors during the hours when the next morning's issue is under way.

Visitors will be shown moving pictures of how timber is cut on the *Tribune's* own reserves in the forest primeval of Quebec, manufactured into paper, transported in their own motor ships to the unloading dock on the Chicago River, where guides will show and explain the many mechanical marvels which have been contrived to handle the huge rolls of paper and the operation of the gigantic high-speed presses, some of which are suspended from unique supports to eliminate vibration.



A broadcast will follow the tour in the adjoining theater studio of WGN, one of the most beautiful of its kind, with forty-five minutes of popular music and entertainment.

Tickets are limited; first come, first served.

PARTIAL LIST OF CERAMIC MANUFACTURING PLANTS IN IMMEDIATE CHICAGO AREA*

Aetna Porcelain Enameling Co., 4701 Augusta St.: dry-process porcelain enameling plant, specializing in jobbing work of all kinds; plant equipped with 4 box-type furnaces for cast-iron enameling (A. L. Vodicka, president).

Austenal Laboratories, Inc., 5932 S. Wentworth Ave.: four periodic kilns; plant makes dental porcelain, teeth, and plates; conducting considerable research on dental porcelains (R. W. Erdle, president; P. William Lee, ceramic engineer).

Brisch Brick Co., 4545 Roosevelt Rd., Cicero, Ill.: common brick, scove kilns; research work on use of soda ash in brick to reduce laminations, increase plasticity, reduce water content needed (Mike Brisch, Sr., president; L. B. Lockie, superintendent).

Carey Brick Co., 6558 Fullerton Ave.: common brick, scove kilns.

Chicago Brick Co., 138th St. and Dorchester, Dalton (Chicago, Ill.): common brick, scove kilns (Mr. Laughlin, superintendent).

Chicago Porcelain Enameling Co., 2028 N. Major Ave.: cast-iron enameling by wet and dry process on jobbing basis (G. O. Claeyssens in charge of enameling).

Chicago Pottery Co., 1920 Clybourn Ave.: two tunnel kilns; manufacture of lavatories, tubs, wash-stands, and other vitreous-china plumbing fixtures and specialties (F. J. Clifford, president; J. S. Clifford, superintendent).

Chicago Vitreous Enamel Product Co., 1401–47 S. 55th Court, Cicero, Ill.: large producers of porcelain enamel frit; latest type of frit-producing equipment and a large modern research and control laboratory (Wm. Hogenson, president; E. Hogenson, Jr., executive vice-president and treasurer; D. B. Walters, vice-president and general manager; B. T. Sweely, director of research).

* The location is Chicago, Ill., unless otherwise specified.

Cribben & Sexton Co., 680 N. Sacramento Blvd.: producers of Universal line of gas ranges; recently modernized enameling department conveyerized for production of ranges; furnaces and other equipment of continuous type (G. D. Wilkinson, president; E. R. Guyer, vice-president; C. E. Lyon, Sr., vice-president; Fred Doering, enamel superintendent).

Crown Stove Works, 4631 W. 12th Pl.: box-type furnace equipped plant for production of Crown line of ranges (W. F. Rogers, president; C. J. Rogers, secretary and general manager; J. L. Bright, superintendent; R. Hamilton, general foreman).

Edison General Electric Appliance Co., 5600 W. Taylor St: one of the largest electric-range producers in the country with modern conveyerized enameling department; much equipment of continuous type for quantity production (G. Hughes, president; A. D. Bylar, vice-president and general manager; E. Scharf, enameling superintendent).

General Porcelain Enameling Mfg. Co., 2700 N. Karlov Ave.: jobbing plant specializing in sign and architectural work (F. E. Hodek, Jr., secretary; G. W. Greene, superintendent).

Illinois Brick Co., Plant 17, 1823 W. 119th St.: makes common brick; 1 scove kiln; capacity to 250,000 per day (William Schlake, president; Hugo Filippi, superintendent); (research laboratory, Charles Filippi, ceramic engineer) (one of the few research laboratories in brick industry).

Inland Glass Works, 6101 W. 65th St.: plant makes 15,000 to 20,000 pieces of blown and pressed glassware daily; mainly borosilicate coffee brewers, lighting equipment of buses, railroads, streetcars, and city streets; mixing bowls, reflectors, floodlight lenses, and specialties; 2 continuous furnaces and 9 day tanks; gas-fired continuous tanks, 40 and 30 tons daily capacity (George L. Chamberlain, president; Howard Parman, ceramic engineer).

Johnson Glass Co., 5248 N. Elston Ave.: plant makes all types of automotive glassware, lenses, headlights, reflectors, etc.; colored and clear glassware specialties; 1 continuous furnace, 5 day tanks, and 10 rings; most ware hand-made, with little automatic equipment (Fred C. Tams, president; G. P. Johnson, factory manager).

National Brick Co., 3150 W. Touhy St.: makes common brick, scove kilns (B. Weber, president).

Northwestern Terra Cotta Corp., 2525 Clybourn Ave.: plant has 1 tunnel kiln and 6 periodic kilns; manufactures hand-thrown and machine-made terra-cotta block and slabs; much development work in terra-cotta slabs for interior decorative uses, as compared to old massive block for structural use (Arthur H. Kaeppel, president and general manager).

Pickard, Inc., 4853 Ravenswood Ave.: address of decorating shop, where a fine type of porcelain is decorated, specializing in all-over crinkly gold, although considerable fine color work is also done; company recently went into production with a pilot plant at Antioch, Ill.; makes a fine type of vitrified porcelain for vases and dinnerware; high class of merchandise sold through Marshall Field and other quality stores (W. A. Pickard, president; H. A. Pickard, general manager; A. G. Simon, production manager).

Western Electric Co., Hawthorne Station: company makes electrical porcelain insulators and specialties exclusively for the company's own use in manufacture of telephones, switches, and other electrical equipment (L. I. Shaw, ceramic engineer).

GOLDEN GATE GENERAL MEETING, SAN FRANCISCO, CALIF., AUGUST 6 12

Meeting Place: Hotel St. Francis

The following Committees from the Northern California Section have been appointed to prepare plans for the General Meeting of the American Ceramic Society, August 6–12, in San Francisco, Calif.

Special Exhibit Committee

E. E. Saunders, *Chairman;* Gladding, McBean, & Co., 1275 Harrison St., San Francisco.
C. W. Kraft, Kraftile Co., Niles.
F. H. Meyer, California College of Arts and Crafts, Oakland.
E. F. Goodner, Standard Oil Co., San Francisco.
B. A. Noble, Owens-Illinois Pacific Coast Co., San Francisco.
Dorsey Lyons, The Industrial West, Inc., San Francisco.

Technical Program Committee

T. K. Cleveland, *Chairman;* Philadelphia Quartz Co. of California, Sixth and Grayson Sts., Berkeley.
Clare Chaffee, Owens-Illinois Pacific Coast Co., San Francisco.
L. N. Gill, American Radiator & Standard Sanitary Co., Richmond.
Frank Raine, Stockton Fire Brick Co., Pittsburg.
E. E. Saunders, Gladding, McBean, & Co., San Francisco.
E. F. Goodner, Standard Oil Co., San Francisco.
Willi M. Cohn, consultant, Berkeley.
Emory M. Smith, consultant, San Francisco.

Plant Visit Committee

George E. Sladek, *Chairman;* Kraftile Co., Niles.
Emory M. Marshall, Stockton Fire Brick Co., Pittsburg.
Wendel Mahaffy, Owens-Illinois Pacific Coast Co., San Francisco.
Bradley W. Wyatt, N. Clark & Sons, San Francisco.

CERAMIC EXHIBIT

The importance of glass and paint in the home of today and the home of tomorrow and a foretaste of the appearance of walls, furniture, and store-fronts of the future are shown in the joint exhibit of the Pittsburgh Plate Glass Co. and the W. P. Fuller & Co. in the Homes and Gardens Building at the Golden Gate International Exposition.

The story of glass and paint is told on two floors which are connected by an escalator. One-half of the first floor is occupied by a small though complete paint mill which shows how paint is made and how pigment is added. The other half is partly taken up with an exhibit of 6 miniature store-fronts (built true to scale) that reflect the future in striking design and construction. The remainder of the first floor is occupied by three laughing mirrors, an entertainment feature; a glass-cutting machine with saw-tooth wheels; and a glass-breaking machine, demonstrating the advantages of safety glass over regular plate glass.

The latest work in the adaptation of glass to the home of tomorrow is also shown. This story is told through the medium of four highly modernistic rooms, living room, bedroom, dressing-room, and sun-porch, which embody the latest interior-decorating ideas. The walls of the rooms are of glass block; glass furniture and the effective use of mirrors are shown. Glass furniture is nonchipping, easily cleaned, decorative, proof against all deterioration but acid, and may be molded to any shape to meet the designer's taste.

WATCH YOURSELF GROW BY GETTING MORE NEW MEMBERS

Report on State of Your Society

Here is the "paid member" scoreboard. Compared with the record a year ago, it shows a net gain of 67 Personal and 8 sustaining Corporation members and also an increase of 80 in paid subscriptions.

All resignations and "noncommunicants" have been cut off.

Only those with "cash on the counter" are counted.

PAID MEMBERSHIP RECORD

Date of Record	Members Paid		Deferred	Subscriptions	Monthly Sales	Total Circulation
	Personal	Corporation				
December 20, 1936	1452	196				
December 22, 1937	1713	220	12	523	220	2688
December 19, 1938	1815	222	26	589	220	2872
January 21, 1939	1792	220	26	610	220	2868
February 18, 1939	1795	225	25	620	220	2885

Our 1939 Meetings

Technical programs for the Forty-First Annual Meeting, Hotel Stevens, Chicago, Ill., April 16–22, are rapidly shaping up. More than 160 papers have been scheduled; several of them are being preprinted.

For the Golden Gate Meeting in Hotel Saint Francis, San Francisco, August 6–12, extensive ceramic exhibits are installed and the technical programs are completed.

The Art Division Meeting program at Blue Ridge, North Carolina, August 16 and 17, is near completion by Kenneth Smith, Newcomb Pottery, Tulane University, New Orleans, La.

The Division Autumn Meetings are being planned.

The Forty-Second Annual Meeting in 1940 will be held in Toronto, Ontario.

NEW MEMBERS*

Corporation

IDAHO FIRE BRICK & CLAY CO., Edward R. Coonley (voter), Troy, Idaho.
NATIONAL GYPSUM CO., F. L. Marsh (voter), 192 Delaware Ave., Buffalo, N. Y.
*OLEAN TILE CO., N. E. Phillips (voter), Olean, N. Y.
VEREENIGING BRICK & TILE CO., LTD., L. Wishart (voter), Box 49, Vereeniging, Transvaal, South Africa.

Personal

COPELAND, RALPH E., Steubenville Pottery Co., Steubenville, Ohio.
FORD, JOSEPH, 738 Centre St., Trenton, N. J.; research work, Star Porcelain Co.
*KRAUS, CHARLES E., Kraus Research Laboratories, Sparks, Md.; ceramist.
*MITRA, H. K., 12, A Road East, Jamshedpur, B. N. R., India; assistant refractories engineer, Tata Iron & Steel Co., Ltd.
ROSSETTI, JOSE, Caixa Postal 278, São Paulo, Brazil; Ceramica São Caetano.
SCHILLER, A. DEWEY, 324 Imperial Ave., Painted Post, N. Y.; foreman mixing dept., Corning Glass Works.
SCHLIENTZ, DONALD T., 52 Grove St., Pittsfield, Mass.; General Electric Co.
SHERIDAN, HARRY H., 2316 E. 38th St., Los Angeles, Calif.; salesman, Victor Belting & Rubber Co.
SHOOK, ELLEN L., Box 145, Ellisville, Miss.; instructor.
TAKAHASI, H., Library of the Hitati Engineering Works, Sukegawa, Ibaraki-ken, Japan.
TOSTLEBE, H. M., General Refractories Co., Box E, Clayton, Mo.; superintendent.
WARD, GEORGE E., 130 Chestnut St., Corning, N. Y.; furnace design engineer, Corning Glass Works.
WORK, HAROLD K., Jones & Laughlin Research Laboratory, 40 Longworth St., Pittsburgh, Pa.; manager of research and development.

Student

Georgia School of Technology: C. K. Chamlee, B. L. Helton, and W. R. Sanderson.
Rutgers University: Charles W. Piez, Jr.
University of Alabama: Edward Forst, Jr.
University of Illinois: W. R. Johnson.
Virginia Polytechnic Institute, Blacksburg, Va.: Robert M. Taylor, Jr.

* Indicates former member of the Society rejoining.

ROSTER CHANGES DURING FEBRUARY†

Corporation

OLD HICKORY CLAY CO., L. F. Powell (voter), Box 271, Paducah, Ky. (formerly in name of R. N. Scott, personal member)
WEST VIRGINIA BRICK CO., Claude F. Wiseman (voter), Charleston, W. Va. (formerly in name of Claude F. Wiseman, personal member)

Personal

BUCK, IVAN, JR., 526 Eleventh St., Niagara Falls, N. Y. (Emporium, Pa.)
CLINE, ROBERT W., Gladding, McBean, & Co., Lincoln, Calif. (Rockport, Wash.)
CONNER, HARVEY, Theta Kappa Nu, Alfred, N. Y. (Avoca, N. Y.)
GEISINGER, E. E., Pfaudler Co., 89 East Ave., Rochester, N. Y. (Schwetzingen, Baden, Germany)
HARTFORD, FRANK M., International Allied Engineering, Corrientes 424, Oficina 249, Buenos Aires, Argentina, South America (Cleveland, Ohio)
HEDQUIST, ALFRED J., 68 Calvin Place, Hamburg, N. Y. (Buffalo, N. Y.)
HELZ, A. W., 45 W. Ninth Ave., Columbus, Ohio (Milwaukee, Wis.)
HOUSER, VICTOR F., 1800 Murphy Ave., S. W., Atlanta, Ga. (Maywood, Calif.)
LONG, J. SHERMAN, Sterling China Co., Wellsville, Ohio (Grafton, W. Va.)
MINTON, L. G., The Chesterfield, 21 Harris St., N. W., Atlanta, Ga. (Seville, Ohio)
MOONEY, WILLIAM F., 4000 Berenice Ave., Los Angeles, Calif. (Steubenville, Ohio)
NIKLEWSKI, BRONISLAW, JR., Mazowiecka 45, Poznan, Poland (Nashville, Tenn.)
PHELPS, NELSON G., Escambron Beach Club, San Juan, Puerto Rico (Washington, D. C.)
STEWART, FRANCIS S., 916 Thirteenth St., Parkersburg, W. Va. (Marion, Va.)
SUTTON, W. J., Fukien Christian Univ., Foochow, Fukien, China (Alfred, N. Y.)
THOMPSON, N. M., c/o J. H. Dunn, Box 132, Springdale, Pa. (Beaver, Pa.)
ZOLLER, MILES M., Eagle-Picher Sales Co., Broadway & East Ninth Sts., Cleveland, Ohio (Cincinnati, Ohio)

Student

SAWYER, JOHN P., JR., 1301 Hillsboro St., Raleigh, N. C. (Elizabeth City, N. C.)
STEARNS, LEONARD F., Box 226, Hopewell, Va. (Malden, Mass.)

† Address in parentheses is the former address.

MEMBERSHIP WORKERS' RECORD

Corporation			
J. F. Chambers	1	Office	3
Personal			
G. C. Betz	1	L. A. Smith	1
H. R. Goodrich	1	R. K. Smith	2
A. de A. Pereira	1	Office	6
G. H. Porter	1		
Student			
A. I. Andrews	1	Lane Mitchell	3
G. H. Brown	1	J. W. Whittemore	1
T. N. McVay	1		
		Grand Total	**24**

NEWS OF MEMBERS

COMMITTEE ON PHARMACEUTICAL GLASS

The Committee on Pharmaceutical Glass serves in an advisory capacity to the Committee on Laboratory of the Council of the American Pharmaceutical Association. Members of the American Ceramic Society who have been appointed to this Committee are as follows:

Chairman: F. C. FLINT, Hazel-Atlas Glass Co., Washington, Pa.
A. N. FINN, Glass Section, National Bureau of Standards, Washington, D. C.
D. E. SHARP and E. O. HILLER, Hartford-Empire Co., Hartford, Conn.
U. E. BOWES, Owens-Illinois Glass Co., Toledo, Ohio.
E. W. TILLOTSON, Mellon Institute, Pittsburgh, Pa.
W. C. TAYLOR, Corning Glass Works, Corning, N. Y.
J. F. GREENE, Kimble Glass Co., Vineland, N. J.

NATIONAL PAVING BRICK ASSOCIATION

The Thirty-Third Annual Meeting of the National Paving Brick Association was held in Columbus, Ohio, February 1–3, 1939. The officers elected for 1939–1940 are as follows: *President,* C. C. Blair (reëlected); *Vice-President,* H. L. Carter (Eastern Region); *Treasurer,* S. Nirdlinger; and *Secretary,* G. F. Schlesinger.

GREETINGS FROM HENRY C. KLEYMEYER

February 8, 1939

This is my first day in the office since November 4, and I am taking this opportunity to write to as many as possible of my good friends, who so kindly remembered me during this long and trying period. I am not yet able to attend to business and shall spend a month in Florida in an effort to recuperate fully.

Your letter states correctly the nature of my injuries; in addition, phlebitis has developed which is still hanging on. The doctor tells me that I will feel the effects of this for possibly six months to a year.

I want to assure you that I appreciated your interest, and I want to thank you and the other members of the Society for their good wishes.

I notice that the Annual Meeting will be held in Chicago in April, and if at all possible, my health permitting, I will be there to mingle again with the old crowd and renew acquaintances.

—H. C. KLEYMEYER

ROGER ROWLAND HONORED

Captain Roger W. Rowland, Secretary of Property and Supplies, Commonwealth of Pennsylvania, was honored with a testimonial dinner given at the Scottish Rite Cathedral, New Castle, Pa., February 4, 1939, which was his forty-fourth birthday anniversary.

Captain Roger W. Rowland

Roger W. Rowland, the son of Mr. and Mrs. Sleigh Rowland, was born in Springfield, Mass., on February 4, 1895, and attended the Springfield Public Schools and High School. He was graduated with the class of 1917 from Pennsylvania State College, where he specialized in electrical engineering.

He then enlisted in the air forces of the United States Army at Plattsburg, N. Y. As Commander of the 1st Pursuit Group, 27th Aero Squadron in France, he was officially credited with bringing down three enemy planes, although he actually brought down five. He was shot down in one engagement and wounded.

Discharged in September, 1919, he became affiliated with the John F. Casey Co. of Pittsburgh, and until 1928 he was located in that city. In 1928, he went to New Castle as President of the New Castle Refractories Co., in which capacity he has served since.

He is married and has two children.

Community Honors*

"In the selection of Captain Roger W. Rowland as Secretary of Property and Supplies in his cabinet, Governor Arthur H. James has done more than honor an individual. He has honored New Castle and the entire County of Lawrence. It is a tribute to any community to have within its borders a man capable enough to be considered as the man for a job of such importance.

"The appointment of Captain Rowland was not a 'political' appointment. Governor James urged that he take the position as Secretary of Property and Supplies, not because of the political importance of Lawrence County, for there are many counties much larger in importance. It was because the Governor wanted a man in this vitally important post who has personal courage and integrity, business training, and executive ability.

"Those of us who know Captain Rowland know that Governor James has made no mistake. As an industrial leader in our County, he has made the New Castle Refractories Co. an outstanding enterprise in its field. As a citizen, he has lent himself to every worth-while endeavor. As the chairman of the Lawrence County Republican Committee, he has proved himself to be an organizer and an executive. As Secretary of Property and Supplies, he will handle the State's money with the same level-headed judgment that has characterized his private endeavors.

"It is an honor that we of New Castle and Lawrence County appreciate to the fullest extent, not only because of the appointment itself, but even more so because of our knowledge and confidence in the man who has received it."

* Excerpts from Testimonial Program.

NECROLOGY

GEORGE W. GOUDY

George W. Goudy, general representative, foreign manager, and director of the Philadelphia Quartz Co., died February 7, 1939, in his sixty-ninth year, at his home in Highland, Ulster County, N. Y. He had been associated with the Company more than 40 years, having first served in the capacity of a salesman, assisting his father, Charles W. Goudy, who was traveling representative. His early experience as a soap manufacturer well fitted him for the position of aiding his father in validating the merits of silicate of soda, particularly in the manufacture of soap and paper.

Through more than 40 years of business life with the Company, he saw the development of wider usefulness of the sodium silicates and, in the early 20th Century, he contributed to the establishment of the fiber box as a standard shipping container.

His kindly philosophy and keen wit endeared him to all who knew him. A favorite motto in dealing with others was, "Is it kind? Is it so? Is it worth while?" His advice was constantly sought by friends in and out of business circles, and so he became "Uncle George" to a great number of people from coast to coast, in Europe, in South America, and across the Pacific. During the last year and a half, illness had prevented him from being active in his official capacity.

AUDIT REPORT OF THE AMERICAN CERAMIC SOCIETY FOR 1938

STATEMENT OF ASSETS AND LIABILITIES

As at December 31, 1938

ASSETS			
Cash in bank (current)		$ 4,899.56	
Revolving fund (bank)		300.00	
Petty cash in office		5.00	$ 5,204.56
Invested reserve (U. S. Savings and Treasury Bonds)			7,958.16
Accounts receivable		3,072.15	
Accrued interest		13.08	3,085.23
Prepaid expenses on 1939 Meeting			40.00
Office equipment (written off)			
TOTAL ASSETS			$16,287.95
LIABILITIES			
Accounts payable		965.63	
Reserve for Fellow dues		1,382.75	
Institute of Ceramic Engineers		108.85	
Deferred income (prepaid)			
Corporation dues	$ 2,162.16		
Personal dues	5,778.04		
Subscriptions	2,225.70		
Orton Medallion	16.00		
For Building Fund	10.00	10,191.90	
TOTAL LIABILITIES AND DEFERRED			$12,649.13
SURPLUS (assets over liabilities)			$ 3,638.82

LOCAL SECTIONS

BALTIMORE-WASHINGTON SECTION

The winter meeting of the Baltimore-Washington Section of the American Ceramic Society was held at the Longfellow Hotel, Baltimore, Md., February 4, 1939.

Following the dinner and short business meeting, the guest speaker, Walter A. Weldon, Locke Insulator Corp., was introduced by Vice-Chairman James D. Tetrick.

Mr Weldon spoke on "Building a Collection of Chinese Ceramic Art" and also read a short paper on the "Origin of the Name Porcelain." In addition to pictures, charts, and a special map of China showing the location of pottery plants, he exhibited examples of Chinese art from his personal collection. Mr. Weldon's outline of his technique in pursuing his favorite hobby gave the members of the gathering an unusually entertaining and instructive evening.

—DONALD HUBBARD, *Secretary-Treasurer*

PITTSBURGH SECTION

The Pittsburgh Section of the American Ceramic Society met in the auditorium of Mellon Institute, Pittsburgh, Pa., February 14, 1939. A talk on "Physical Properties of the Glaze Film" was presented by J. H. Koenig, Hall China Co., East Liverpool, Ohio.

NORTHERN CALIFORNIA SECTION

Committee Reports

Sixty members of the Northern California Section attended a meeting on February 6, 1939, at the Robin Hood Inn, Oakland, Calif. A. S. Adcock, Chairman, was the presiding officer.

E. E. Saunders, Chairman of the Exhibit Committee for the ceramic display in the Mining Building at the Golden Gate International Exposition, reported that the ceramic exhibit is being set up in the offices of Gladding, McBean, & Co. The exhibit is to be divided into 4 main groups and will be moved to Treasure Island after the selections are completed. Selected products from the ceramic industries of the eleven western states will be used. Pictures and drawings showing various processes will be in the background, and the story of ceramics will be told by means of revolving pictures within the exhibit. Mr. Saunders and his Committee have devoted much time and labor to this exhibit, and the members of the Northern California Section may well be proud of this splendid piece of educational work.

T. K. Cleveland, Chairman of the Program Committee for the General Meeting to be held in San Francisco, August 6–12, 1939, reported that the Committee has decided to schedule 16 papers for this Meeting. Twelve papers have been selected; several other papers are available, but the titles have not been determined.

C. W. Kraft, Vice-Chairman of the Northern California Section, outlined ideas for forthcoming meetings of this Section. One meeting will be devoted to a subject outside of ceramic technology, and "Personnel Management" was suggested for a meeting topic.

Bradley W. Wyatt of N. Clark & Sons extended an invitation to the Section to visit the Alameda plant of N. Clark & Sons, and definite plans will be made for this plant visit.

Lecture by Dr. Jenkins

The speaker for this meeting was Olaf P. Jenkins, Geologist for the State of California, whose topic was "Distribution and Geologic Occurrence of Clays in California." The lecture began with a description of the time of the formation of clays. The various geologic periods and the clay-forming minerals and rocks were discussed. The geologic formations were illustrated with slides; it was shown that the areas of importance, which are the present commercial operation of clay-mining companies, are related to a definite geologic formation. A discussion and question period followed this talk.

W. W. Bradley Shows Kodachrome Slides

Walter W. Bradley, Mineralogist for the State of California, presented a series of Kodachrome slides of economic clay deposits and operations. The colored slides illustrated the various strata within deposits much better than the usual black and white slides. Various operations of mining clay over the entire State were presented, as well as a good collection of colored slides showing the use of ceramic products in the construction of buildings.

Mr. Bradley spoke of the importance of the ceramic industry, the fourth largest industry in California.

After Mr. Bradley's talk, the meeting was opened for questions. A question was raised as to why the State Division of Mines no longer carries on surveys of the existing clay deposits. Mr. Bradley stated that there is a definite need for a large amount of survey work upon the clay deposits and that an incentive for the development of future deposits should be created.

A motion was made by Mr. Goodner that the Chairman appoint a Committee on Ways and Means to study this matter and to report to the Section on the proper steps to be taken to get a survey started upon the clay resources of the State of California; the motion was seconded by Dr. Cohn and was passed.

The Northern California Section hopes to assist in the development of the ceramic resources of the State for present and for future use.

—G. A. PAGE, *Secretary*

December Meeting, 1938

At the meeting held on December 5, 1938, the following officers of the Northern California Section were elected for 1939:

Chairman: A. S. Adcock, American Radiator & Standard Sanitary Co., Richmond, Calif.

Vice-Chairman: C. W. Kraft, Kraftile Co., Niles, Calif.

Treasurer: Graham G. Smith, N. Clark & Sons, 116 Natoma St., San Francisco, Calif.

Secretary: G. A. Page, Stockton Fire Brick Co., Pittsburg, Calif.

ST. LOUIS SECTION

The next meeting of the St. Louis Section of the American Ceramic Society will be a dinner meeting at Garavelli's Restaurant in St. Louis, Mo., March 29, 1939. The program is as follows:

(1) Motion Picture, "Materials." Courtesy of General Motors.

(2) "The Wagner Turbidimeter as a Means of Measuring Grain-Size Distribution of Ceramic Materials," by L. A. Wagner, Missouri Valley Portland Cement Co.

(3) "Thermal Dissociation of Diaspore Clay," by Paul G. Herold, School of Mines and Metallurgy, Rolla, Mo.

(4) "Solid Phase Reactions Applying to Barite," by F. J. Williams, National Lead Co., St. Louis, Mo.

During the business portion of the meeting, the slogan, "On to the Chicago Meeting," will be stressed.

—PAUL G. HEROLD, *Secretary*

CERAMIC SCHOOL NOTES

OHIO STATE UNIVERSITY

The Ohio State University Student Branch, American Ceramic Society, held its regular monthly meeting on February 15 in Lord Hall, O.S.U. C. J. Koenig, Engineering Experiment Station, spoke on "Sales Engineering in the Ceramic Industries." This was the first of a series of scheduled talks designed to cover the various types of ceramic engineering jobs.

VIRGINIA POLYTECHNIC INSTITUTE

The Virginia Polytechnic Institute Student Branch of the American Ceramic Society was presented its Charter by V. V. Kelsey, president of the American Ceramic Society, at a banquet on January 19 in the Faculty Center. The membership totals 32 students, including graduates and undergraduates, and John W. Whittemore and Paul S. Dear, professor and assistant professor of ceramic engineering, respectively, as honorary members.

Mr. Kelsey, president of Dominion Minerals, Inc., spoke on the rapid growth and development of industrial ceramics, and he stated that although ceramics is one of the oldest arts known to man, it is young as a science. He concluded by quoting Edward Orton, Jr., organizer of the American Ceramic Society, who throughout his career stressed the necessity of coöperation and the sharing of ideas as the only basis for progress in the industry and for personal satisfaction.

R. G. Charles, president of the Student Branch, accepted the Charter on behalf of the Virginia Tech branch. Professor Whittemore outlined the history of ceramics at Virginia Tech, and Colonel Earle B. Norris, dean of engineering, spoke about some of the outstanding achievements of the ceramic engineering department. James D. Braddock served as toastmaster.

—W. H. HITT, *Secretary*

RUTGERS UNIVERSITY

Ernesto Franco of Ecuador, South America, delivered a lecture on "South American Pre-Columbian Civilization and Ceramics" at a joint meeting of the Rutgers Ceramic Club and Ceramic Association of New Jersey in New Brunswick, N. J., on February 13.

Dr. Franco is a graduate of the National Institute of the Republic of San Salvador; his graduate work was completed in American universities, with a civil engineering degree from Lehigh University and a Ph.D degree from Columbia University.

By means of excavations carried on for many years along the coast, rivers, inlets, and in some partially submerged areas of Esmereldas (the northernmost province on the coast of Ecuador), as an archeologist of the country, Dr. Franco has brought to light a collection of sculpture and ceramics that marks the height of artistic achievement in the ancient civilization of the western hemisphere.

In the preparation of his lecture, Dr. Franco collaborated with R. Requena, an international authority on the Pre-Columbian civilizations of Venezuela and Peru and widely known for his theory of the origin of civilization in the Western rather than in the Eastern hemisphere. Dr. Requena (who recently spoke at Yale University) was present at the meeting and showed specimens of ancient South American art which will be exhibited at the New York World's Fair in connection with his theory. These have not been shown previously in this country.

The lecture was also supplemented by a display of various ceramic specimens, slides, and photographs pertaining to Dr. Franco's subject.

An audience, consisting mainly of Rutgers students and faculty and representatives of ceramic industries in New Jersey and neighboring states, attended the meeting. Refreshments were served.

—G. GOODMAN, *Recording Secretary*

PAUL L. SMITH, RESEARCH ASSOCIATE PORCELAIN ENAMEL INSTITUTE

Paul L. Smith of the National Bureau of Standards, Washington, D. C., has been reappointed for 1939 as research associate of the Porcelain Enamel Institute.

Dr. Smith has been conducting technical research projects for the Institute since his original appointment in August, 1937.

A native of Bloomington, Ill., Dr. Smith received his B.S. degree in Physics from Illinois Wesleyan University in 1934. He then began graduate work at the University of Illinois and at Pennsylvania State College, and received his M.S. in Ceramics at Penn State in 1935. For the years 1935–1937, Dr. Smith was Orton Fellow at Penn State. He worked on the "freezing" of pyrometric cones and on the diffusion of gases through glass, completing the requirements for the Ph.D degree in ceramics in 1937.

For a number of years the porcelain enamel industry has realized the need for standardizing test procedure, and Dr. Smith's work is being directed toward that end. The tests for acid resistance and abrasion resistance with which he has assisted have been accepted by the industry as standards for porcelain enamel.

PROCEEDINGS OF PORCELAIN ENAMEL INSTITUTE

The Proceedings of the Third Annual Forum of the Porcelain Enamel Institute is available. The book (228 pages) contains a complete record of the papers presented and verbatim reports of the discussions that followed during the Forum meetings held at the University of Illinois, October 12 to 14, 1938. Copies may be obtained at $2.00 each from the Porcelain Enamel Institute, 612 N. Michigan Ave., Chicago, Ill. Upon request, a copy of the Proceedings of the First Annual Forum (regular price, 50 cents) and the Second Forum (regular price, $2.00) will be included without charge with any order for the present volume.

OFFICERS OF FELLOWS FROM 1930 TO 1939

1930: EDWARD ORTON, JR., Acting Chairman; C. B. HARROP, Temporary Secretary.

1931: EDWARD ORTON, JR., Chairman; C. B. HARROP, Secretary.

1932: G. A. BOLE, Chairman; L. E. BARRINGER, Vice-Chairman; C. B. HARROP, Secy.-Treasurer.

1933: L. E. BARRINGER, Dean; P. E. COX, Associate Dean; C. B. HARROP, Secy.-Treasurer.

1934: C. W. PARMELEE, Dean; F. H. RIDDLE, Associate Dean; G. H. BROWN, Secy.-Treasurer.

1935: F. H. RIDDLE, Dean; A. S. WATTS, Associate Dean; G. H. BROWN, Secy.-Treasurer.

1936: A. S. WATTS, Dean; M. C. BOOZE, Associate Dean; G. H. BROWN, Secy.-Treasurer.

1937: E. P. POSTE, Dean; LOUIS NAVIAS, Associate Dean; R. K. HURSH, Secy.-Treasurer.

1938: P. E. COX, Dean; W. K. MCAFEE, Associate Dean; R. K. Hursh, Secy.-Treasurer.

THE INSTITUTE OF CERAMIC ENGINEERS

Executive Committee
President: A. F. GREAVES-WALKER
Honorary Past-President: F. L. STEINHOFF
Vice-President: J. L. CARRUTHERS
Secretary: C. M. DODD
Trustee Representative: R. E. BIRCH

Report of Nominations Committee

The Nominations Committee (J. W. Whittemore, Chairman) has submitted its report with the following nominees for 1939:

For President: J. L. CARRUTHERS, Ohio State Univ., Columbus, Ohio.

For Vice-President:
- H. N. BAUMANN, JR., Carborundum Co., Niagara Falls, N. Y.
- H. G. WOLFRAM, Porcelain Enamel & Mfg. Co., Baltimore, Md.

For Secretary:
- C. M. DODD, Missouri School of Mines and Metallurgy, Rolla, Mo.
- S. J. MCDOWELL, General Ceramics Co., Keasbey, N. J.

The election of officers will be held at the annual meeting in Chicago, Ill.

Membership

From the membership provisions founded on the Rules of the Institute,* a system of evaluating applications has been determined. Undoubtedly there are some who are still in doubt as to their eligibility to membership. If these questions are not answered by the accompanying chart and statement, you are urged to write to A. S. Watts, Chairman, Committee on Membership and Examinations. The greatest misunderstanding has arisen from the requirement of an "examination" for admission to Member grade. A legal engineering license is accepted as equivalent. Furthermore, an oral examination, and in some cases examination of bibliographic data or of other evidence of professional attainment, is considered to fulfill this requirement.

Members are urged to make certain that the eligible engineers among their associates do not neglect to apply for membership.

Application blanks for the Institute may be obtained from the offices of the American Ceramic Society.

In filling out the blank, if any doubt exists as to the membership grade for which to apply, the applicant is urged to leave this option to the Committee on Membership and Examinations.

* *Bull. Amer. Ceram. Soc.*, **17** [10] 395–98 (1938).

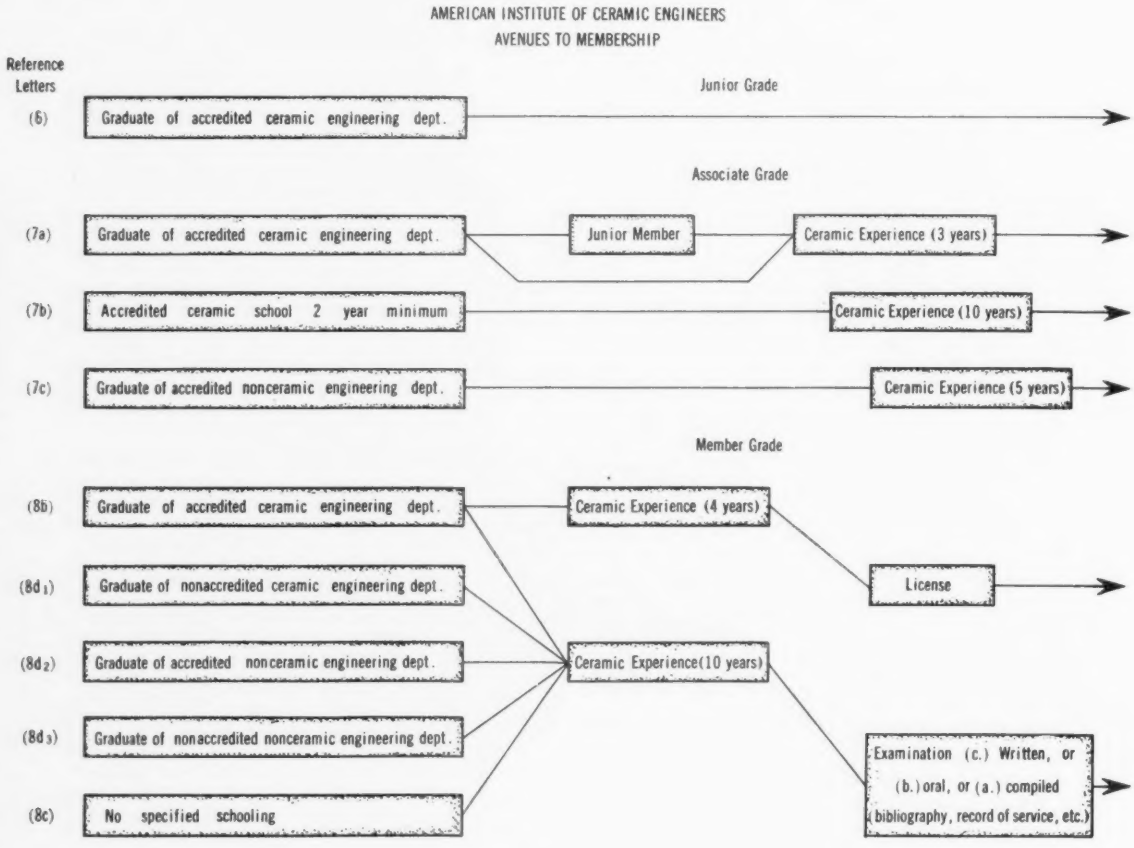

AMERICAN INSTITUTE OF CERAMIC ENGINEERS
AVENUES TO MEMBERSHIP
Reference Letters
Junior Grade
(6) Graduate of accredited ceramic engineering dept.
Associate Grade
(7a) Graduate of accredited ceramic engineering dept.
Junior Member
Ceramic Experience (3 years)
(7b) Accredited ceramic school 2 year minimum
Ceramic Experience (10 years)
(7c) Graduate of accredited nonceramic engineering dept.
Ceramic Experience (5 years)
Member Grade
(8b) Graduate of accredited ceramic engineering dept.
Ceramic Experience (4 years)
License
(8d1) Graduate of nonaccredited ceramic engineering dept.
(8d2) Graduate of accredited nonceramic engineering dept.
Ceramic Experience(10 years)
(8d3) Graduate of nonaccredited nonceramic engineering dept.
Examination (c.) Written, or (b.) oral, or (a.) compiled bibliography, record of service, etc.)
(8c) No specified schooling

FIG. 1.—The reference letters correspond to paragraph numbers in Article EIR III of the Rules, *Bull. Amer. Ceram. Soc.*, **17** [10] 395–98 (1938).

CERAMIC HISTORY

HISTORICAL SKETCH OF ARMOUR INSTITUTE OF TECHNOLOGY*

No more typically American story of the founding of an American educational institution could be presented than that of the Armour Institute of Technology. It does not begin with the opening of its doors in September, 1893. It goes back to a mission Sunday-school in which Joseph F. Armour, a merchant with considerable means, was interested and to which he contributed liberally for its support.

This mission, started in 1874, three years after the Chicago fire, and located in a building previously occupied by a saloon, at Thirty-First and State streets, was called Plymouth Mission because it was an extension of the activities of Plymouth Church, of which Joseph F. Armour was a member.

Bequest of $100,000 to Establish Armour Institute

When Joseph F. Armour died, in 1881, he left a bequest of $100,000 to be used by his brother, Philip D. Armour, to establish a Sunday-school for the people of the community. To this amount, Philip D. Armour added $100,000 of his own; and after sending an emissary abroad to study buildings used for mission purposes, he built the "Armour Mission" and turned it over to Plymouth Sunday-school.

Frank W. Gunsaulus, a young man in his thirties, who ten years earlier had been a Methodist circuit-rider in Ohio but was now a silver-tongued orator and pastor of a large and wealthy Chicago church, declared what he would do if he had a million dollars. He would establish a school to help young people who wanted to help themselves.

"Do you believe in those ideas you have just expressed?" the rich merchant asked the poor minister after the service. "I assuredly do," was the firm response. "Would you carry them out if you had the means?" the packer questioned. "Most certainly," said the preacher. "Very well," replied the decisive Armour. "If you will give me five years of your time, I will give you the money."

Frank had preached his way through college, and as an itinerant preacher had moved many a man to repentance. Philip, when only nineteen years of age, had set out from Stockbridge, New York, in 1851, with three other fellows, determined to walk to California to dig for gold. In five years, he had saved up $8000 (perhaps more) of ditch-dug gold.

Young Armour eventually landed in Milwaukee, Wisconsin, where, with $500 of his fortune he formed a partnership in a produce and commission business and later a partnership in meat packing. Then came the Civil War, a demand for their meats, and a fortune for the partners.

Planning a New School

Gunsaulus and Armour were not sure, despite the sermon, what kind of school they wanted to build. Only one thing they were certain of, *viz.*, it was to be practical and to be designed for young people who wanted to help themselves.

Armour and Gunsaulus began collecting data, making careful inquiry into the workings of philanthropic institutions not only in this country but also in Europe.

School of Technology, Frank W. Gunsaulus, First President

As their building grew larger and took shape, they realized that their early aims were not sufficiently inclusive. They had planned a scientific academy as the center, around which were to be various schools or departments. But now they had enlarged the scope. The old academy was no longer the heart, but a technical college, with departments of mechanical and electrical engineering, architecture, and library science, and other departments or schools of domestic arts, of commerce, of music, and of kindergartens. On December 1, 1892, Frank W. Gunsaulus took office as the first president of Armour Institute.

P. D. Armour Dies

The year 1901 was a most important one. Dr. Gunsaulus had resigned the presidency during the previous summer because of ill health, and the school was in the hands of an acting president, V. C. Alderson.

Philip D. Armour, likewise, had been ill, suffering from heart trouble, and on January 6, at the age of sixty-eight, he passed away.

The amount of the investment in Mission and Institute was said to be nearly three million dollars.

Three months later, Mrs. Philip D. Armour and her son, J. Ogden Armour, added another million dollars to that investment and urged Dr. Gunsaulus to resume his presidency, after an absence of eight months, to assist in planning an even larger school.

In 1901, to meet the expanding requirements of the course in mechanical engineering, Machinery Hall was constructed at a cost of more than $100,000, a gift of Mrs. P. D. Armour and J. Ogden Armour. This building was ready for use at the opening of school the following year.

Dr. Frank W. Gunsaulus died on March 17, 1921, at the age of sixty-five. Of his thirty-four years as a citizen of Chicago, at least thirty years had been spent on the Armour Institute of Technology, which had become the primary object of his life. He was preëminently a man of action, and possessed a genius for administration.

In 1933, Dr. Willard E. Hotchkiss accepted the presidency of the Institute and proceeded with the development of the program indicated in the Armour Plan. Until this time, Armour Mission and Armour Institute of Technology had existed as separate corporations, but inasmuch as the Mission had been inactive for several years and its buildings had been used by the Institute, in 1934 the Mission and the Institute were legally consolidated into a single corporation known as Armour Institute of Technology.

Creation of the Research Foundation

The translation of the Armour Development Plan into policy, procedures, and courses of study has meant increased contacts with the research division of industry and an increasing opportunity upon the campus for advanced scientific study and research. The growing importance of research in April, 1936, led to the creation of the Research Foundation. The Foundation is occupied both with research for industry and with basic independent research. On September 1, 1936, all of the research carried on in the laboratories of the Institute was incorporated in the program of the Foundation. The staff of the Foundation is made up of a group of scholars distinguished in their respective fields, some of whom confine their activities to research while others are occupied both with research and teaching. Practically all of the projects of the Foundation give opportunity for the employment of graduate students in the field of their special scientific and engineering training, thus furnishing an important stimulus to graduate study.

On January 1, 1938, the Foundation adopted a fixed schedule of charges. In the experimental engineering division, fees for services are determined in advance and depend upon the time, facilities, and personnel involved. In the industrial research division, the standard fee for a research project is $500 per month and, except in special cases, the project is underwritten for a minimum period of

* Excerpts from *Armour Engineer and Alumnus*, **2** [4] (1937).

six months. This charge covers a suitable laboratory, all available required equipment, the full-time services of one research worker or the equivalent, general supervision by the Director of Research, and, in addition, such service of the general staff as is deemed necessary to expedite the investigation properly and to the best interests of the sponsor. Occasionally a half-time project is underwritten at $300 per month.

Each project is guided by an advisory committee which includes sponsor representation. The field of investigation embraced by an industrial research project is reserved exclusively for the benefit of the sponsor for the duration of the project. Agreements covering industrial research projects provide for patent rights, monthly and final reports, and the execution of the investigation and treatment of findings in strict confidence.

COMMUNICATIONS

USE OF SANTOMERSE TO REDUCE SURFACE TENSION AND DECAL WATERMARKING*

By Elmo H. Lintz

Watermarking of dinnerware is the result of drops of water drying on the ware after the decal paper has been washed off, leaving a deposit which is fired into the glaze surface in the decorating kiln.

The Engineering Experiment Station at Ohio State University has conducted research on the addition of different reagents which would reduce the surface tension of the water in which the ware is to be washed. The results of this investigation were published.[1]

The material which gave the best results in the elimination of watermarking was Saponin, which has been used in most of the dinnerware plants with success.

Since the introduction of Saponin, other materials have been developed for the same purpose, *e.g.*, Areskap and Santomerse, which are manufactured by the Monsanto Chemical Co.

In the use of Saponin, a defoaming agent (Turkey-red oil) is necessary if the water is agitated as in the decal machine. Because the use of Turkey-red oil caused more frequent cleaning of the machines, studies were conducted to eliminate its use.

The properties of Saponin and Santomerse were compared by making up solutions of each material of various concentrations and then by measuring the rise of the liquid in a capillary tube. Comparative values only were obtained which are not actual surface-tension measurements.

The apparatus[2] consists of a capillary tube with a 0.4-mm.-diameter bore, which passes through a cork fixed in the neck of a tube, $^3/_4$ cm. in diameter, in which the liquid to be tested is placed. On the capillary tube, a mm. scale, ruled on opal glass, is attached and held in fixed position by two small hooks sealed to the wall of the capillary tube.

Solutions, containing 0.025, 0.05, 0.1, and 0.2% by weight of Saponin and Santomerse in tap water, were made up. The temperature of the liquid was kept at 25°C ± 0.5.

About 10 to 15 cc. of the liquid to be tested was introduced into the tube, and the capillary tube and scale were placed in position with the zero mark on the scale at the top of the liquid. The liquid was passed up and down the capillary tube by blowing and sucking through a side inlet near the top of the tube, which caused the walls of the capillary tube to be completely wetted. Two readings of the final position of the liquid were taken after the liquid was forced to rise (by blowing) and to fall (by sucking). These readings agreed within 2 mm., and the averages were taken.

(%)	Saponin	Santomerse
0.025	7.25	7.10
0.05	7.15	6.75
0.10	6.30	4.20
0.20	5.90	3.10

Tap water at 25°C = 7.3

Santomerse is shown to be more effective in reducing surface tension than Saponin, assuming that the rise of the liquid in the capillary tube is an indication of the surface tension of the liquid.

In actual use, it was found that Saponin could be replaced with Santomerse and that no defoaming agent was necessary in the decal machines.

Watermarking was absent, and the results were satisfactory with one exception. The decorating shop reported that, where it was necessary to do any lining (that is, decorating with a line at the edge of the plate), the line showed a tendency to break and run down the rim of the plate. This usually happens when there is a grease spot or film on the ware at the time the line is applied. On straight decal patterns, the use of Santomerse to eliminate watermarking was satisfactory. From any economy standpoint, Santomerse has a decided advantage. The price of Saponin is $1.15 per lb. as compared to 17 cents per lb. for Santomerse.

Taylor, Smith, and Taylor China Company
Chester, West Virginia

* Presented at the Autumn Meeting of the White Wares and Materials and Equipment Divisions, Bedford Springs, Pa., September 15–17, 1938.

[1] G. A. Bole, "Method for Eliminating Water Marks on Whiteware," *Jour. Amer. Ceram. Soc.*, **14** [6] 454–56 (1931).

[2] A. Findlay, Practical Physical Chemistry, 5th ed. Longmans, Green, & Co., Ltd., London, 1931.

DON'T INSTALL DE-AIRING
WITHOUT RESEARCH
Special Investigations
JOHN P. DALTON
Technical Ceramics
121 Ward Parkway Kansas City, Mo.
Cable Address: CERAMIX
Reg.

CELO KYANITE
UNIFORM QUALITY DEPENDABLE SUPPLY
FOR INFORMATION AND SAMPLES WRITE TO
CELO MINES, INCORPORATED
BURNSVILLE, NORTH CAROLINA

CREATIVE DEVELOPMENT VISION IN CERAMIC INDUSTRIES*

By Ross C. Purdy

Mr. Toastmaster, Ladies, and Gentlemen: This subject was assigned. I did not choose it. Necessary is it, therefore, that the words used be defined so that I, as well as you, may know what is to be discussed. The following are suggestive definitions:

Creative: Having power, quality, and ability to bring into being—to cause to exist.

Development: The act of disclosing that which is unknown; a gradual unfolding process.

Vision: Act of seeing; perception.

Ceramic: The art of making useful objects from nonmetallic minerals; "fired stuff."

Industries: Systematic and habitually diligent employment for the creation of value.

Another way of stating the subject of this address is "a systematic and habitually diligent use of vision in the creating of new, useful, and valuable ceramic objects," with emphasis on vision and diligence.

It is not alone to the designer of shapes and decorations; it is not alone to the discoverer of required ceramic material combinations; it is not alone to the inventor and operator of processes, but it is also to the managers of a staff of ceramic artists, technologists, engineers, and salesmen that this subject gives the slogan, "Systematic and Habitually Diligent Employment of Vision in the Creation of Value."

This is the essence of industry, of creative art, of ceramic engineering, and of ceramic science.

Shortage in system, vision, or diligence is as defeating in ceramic art, science, and technology and trade as is shortage in cash, no matter whether that shortage be honest or dishonest.

To be systematic, there must be a planned organization with definite assignment of responsibilities.

To have diligence, there must be a profit incentive. To those who have dollars invested, this profit incentive is cash return. To the artistic creator, this profit incentive is the creation of objects having sales appeal. To the ceramic technologist and engineer, this profit incentive is low-cost production of quality ware.

May it be repeated—there can be no power, quality, or ability to bring useful things into being without vision, system, diligence, and profit. These are the essentials in industrial creative development, just as in all human enterprises. They admit of no personal selfishness or dishonesty.

The creative vision in an industrial organization must be comprehended and practiced alike by the artist, the scientist, the engineer, the salesman, and the manager. Each responsible person in a given organization should share in and contribute to the one and same product vision according to his assignments and to his talents. The organization should be blue-printed to systematize most effectively the creative part assigned to each responsible person, but any blue-printed designation of responsibilities that limits the vision of anyone to his assigned department will weaken the organization as a whole. The vision, the act of seeing, and the perception by each and by all of the whole are required to do the job of creating, producing, and marketing a product.

This "all for one and one for all" organization does not mean that each should have and should be able to use the same artistry, science, technology, and business acumen. No, indeed. Each of us has been blessed by nature with very distinctive talents. Each of us has developed his talents. In a well-rounded, systematically operated industrial organization, each position of responsibility is held by one who is peculiarly qualified by cultivated talents to accomplish his assigned tasks. But the artist, the scientist, the engineer, the salesman, or the manager will not be able to do his tasks most effectively unless, by ability, desire, permission, or by requirement, he comprehends the entire setup for creation, production, and selling.

This vision must not be bounded by departments or factory. It must extend to the ultimate buyer of the product. A research organization without product development and promotion is without productive incentives. The departments of design, research, and production should have a place on the sales firing line. They should be exploring, with the sales department, the market possibilities and requirements, and the sales department should be interested in the work involved in developing and producing the products. And through and over all, there should be rigid control of and adherence to standards in performances with a strict respect of the authority of each head in his respective department.

Provincialism in vocations will dwarf one's talent and limit one's vision. A designer who is confined to his studio and whose knowledge of trade possibilities is obtained only by conversations with salesmen and by exhibits of competitors' ware will become too provincial to be of much lasting value.

If a designer is not a confidant of the ceramic technologist, the engineer, and the production manager, he is without needed information and inspiration. There should be no withholding of information; there should be no professional secrets; there should be the fullest possible confidence and exchange of knowledge and discussion of possibilities.

When the entire staff is contributing to the creation and development of a product, then, and only then, will the organization have the requisite vision and be inspired to give themselves to systematic and habitually diligent employment of their talents for the creation of objects of value with profit to all concerned.

This is no pipe dream or idealistic picture. It is a statement of a very realistic performance in ceramic industrial plants noted for being leaders in their respective fields. I have been (and frequently am now) a participator in scheduled conferences of designers, scientists, shop operators, salesmen, auditors, and managers from whom no information is withheld.

Coming together plus keeping together plus working together makes for progress for individuals, industries, and nations. Thus civilization was started and thus it is perpetuated.

The ceramic designer, what qualifications must he possess?

No ceramic concern can afford to employ a person whose only talent or attribute is designing unless they wish to produce museum specimens—works of art without regard to cash profit.

When studying ceramics, my production experience was limited to end-cut, side-cut, re-pressed, soft-mud, and dry-pressed brick. Our studies on ceramic compounding were without a knowledge of products, their production, and use. When I went to the Mosaic Tile Company, I was continued exclusively in laboratory work until that Company undertook to make in mosaic tile the picture of the "Landing of Columbus," which has for nearly four decades decorated the Catholic Church, located at the east end of Main Street in Zanesville. The mosaic facings on those dry-pressed, 6- by 6-inch tile are in vitreous and clay colors of all shades. It is beautifully conceived, the work of Herman Mueller. Mr. Mueller and his brother devised the stencil screens by which this picture was made.

In the early attempts, the colored mixtures shrank unequally, and the kilns varied so in heat distribution that the same colors varied greatly in shade. Finally, I was put up against this commercial production problem. The mixes were changed, the kiln firing procedure was

* Dinner Address presented at a joint meeting of the Art Division and Pittsburgh Section, American Ceramic Society, University of Pittsburgh, Pittsburgh, Pa., January 10, 1939.

corrected, and the picture was finally produced. It was a costly experience, but the most costly part was the fact that the production procedures employed were not adopted by the plant. This was the last of Mr. Mueller's mosaic pictures on 6- by 6-inch tile. His ideal and very practical mosaic tile conceptions were killed because they required mixtures and firing procedures that were new and not acceptable to the plant staff. There was a lack of "coming together, keeping together, and working together."

Quite different was the situation at the Roseville Pottery. There I saw Frederick H. Rhead and John Herold successfully producing products that met market demands. Rhead was trained in English pottery schools and factories as a designer. Herold was a cathedral-glass artist before entering the Zanesville potteries. These two men influenced me more than they knew.

Both Rhead and Herold had knowledge and skill in practical ceramic technology and engineering far beyond that possessed by me. They knew ceramics. They contrived mixtures, processes, and equipment, and made a variety of artware that was sold at prices which varied from $10.00 a gross to $10.00 a piece. They knew the market for such ware.

The important lesson I learned was that before I could be as broadly qualified as were they in ceramic technology and engineering I would have to broaden my vision and my contacts. I came to a realization that the training received in school was only a foundation on which I would have to learn how to build. I became (and am yet) very critical of the objectives which the ceramic schools then had and now have. They fail to teach the fundamentals of creative development vision.

It was at the Norton Company that I learned the benefits of solidarity in factory personnel. There were scheduled meetings of operating foreman, often with sales, promotion, and control departments where trade secrets were not withheld, all with the objective of producing with the greatest exactness and at the lowest cost the products required by Norton customers. Product development and promotion was the objective of the entire staff.

Into such blue-printed organizations, new recruits came whose previous trainings were special and narrow. The position on the team for which each was particularly qualified was soon determined. Those who diligently sought ways and means of acquiring creative development vision were the ones who succeeded in obtaining positions of responsibilities.

Mary Louise McLaughlin* of Cincinnati, now ninety-one years old, possesses a creative development vision to an unusual degree. At the Centennial Exposition in 1876, she saw an exhibit of underglaze slip painting on vases made by Haviland. She was an artist, trained in woodcarving, china painting, and leather- and metal-working. She possessed unusual artistic talent. She was broadly educated in languages, literature, and history. She was a musician. In these talents, she did not differ from several other ladies who saw that same exhibit. It was, however, only Miss McLaughlin who, without experience or knowledge of ceramic mixtures and processes, thought out the manner in which that ware was produced. She sent for the materials. Her first piece is now at the Pennsylvania Museum. She started underglaze slip painting that Rookwood Pottery has commercialized and has brought to high perfection.

Not being interested in using her artistic ability in commercial production, Miss McLaughlin discontinued her work in ceramics until she desired to reproduce Chinese porcelain. Again without ceramic knowledge and skill, she installed a pottery in the basement of her home and a kiln in her back yard. She produced one-fired porcelain artware that simulated the glaze and colors of Chinese porcelain. Much of the ware she produced is in museums. After solving the problem of copper reds, eggshell textures, crackles, and inlaid decorations, she was contented. She had achieved.

A young man in Dearborn, Michigan, working at Ford's, has had two years of collegiate training. He is by training a physicist and a chemist. He has had no ceramic training, but he became possessed with the urge to reproduce Chinese celadons and other so-called "lost colors." He promptly succeeded not only in solving the ceramic problems involved but in reproducing the ware, including the incised decorations and cut-outs.

What is the secret of those ceramic artists—many in number they are—who like Rhead, Herold, McLaughlin, and Foster have achieved notable ceramic success without preparatory training in ceramic technology or engineering?

It is "systematic and habitually diligent employment of vision in the creation of value."

They have objectives. They collaborate with others. Their minds are broadly trained and receptive. They work diligently.

This same creative vision and diligence must be possessed by all who have responsible positions in industry.

John A. Foster

* Editor's Note: Miss McLaughlin passed away January 17, 1939.

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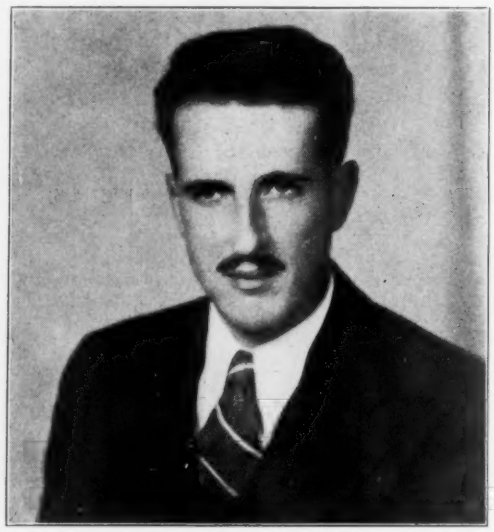
EDWARD ORTON, JR., CERAMIC FOUNDATION

FUNDAMENTAL RESEARCHES FINANCED

The Foundation is continuing four Fellowships at the University of Illinois, Rutgers University, Pennsylvania State College, and Ohio State University, respectively.

Armin W. Helz Employed

Armin W. Helz has been employed to do fundamental research in the laboratories of the Foundation, 1445 Summit St., Columbus, Ohio. Dr. Helz's training and activities to date are as follows.



Armin W. Helz

Education

1926–1930: Univ. of Wisconsin (B.S in Chemistry); courses in qualitative, quantitative, organic, and physical chemistry; electro- and thermo-chemistry; bacteriology; and numerous courses in physics and mathematics.

1930–1931: Michigan College of Mining and Technology (M.S. in Chemistry); courses in physical chemistry, vacuum tubes, and thermodynamics; studied flotation and colloid chemistry.

1931–1935: Univ. of Michigan (A.M. in Physics); courses in colloid chemistry, advanced mathematics, and in all branches of experimental and theoretical physics; special emphasis on electronics and spectroscopy.

1935–1938: Rutgers Univ. (Ph.D); studied crystallography, glass technology, and microscopy.

Research Experience

1935–1938: Thesis, "Viscosity Studies of Dickite Suspensions"; designed and built viscometer; assisted in industrial problems; carried out thermal-expansion measurements of glass for industry.

1931–1935: Research in spectroscopic analysis, infrared, and electronics; worked on development of high-intensity helium light; carried out routine analysis of alloy used in spark plugs by rapid spectroscopic method; considerable experience in optics, photography, and vacuum tubes.

1930–1931: Thesis: "Studies in Flotation"; experience in colloids; designed and built surface-tension apparatus. Published in part, *Jour. Amer. Chem. Soc.*, **57**, 796 (1935).

1929–1930: Thesis: "Electrical Method for Production of N_2O_5 from Air."

Positions

(1) Research Fellow at Michigan College of Mining and Technology; (2) State College Fellow at Univ. of Michigan and part-time Engineering Research staff; (3) instructor and research assistant at Rutgers Univ.; for 1936–1938, the Edward Orton, Jr., Ceramic Foundation Fellow; taught electrical measurement, pyrometry, and gas analysis in Ceramic Dept.

Societies

Sigma Xi, Gamma Alpha, American Ceramic Society, and American Physical Society.

THE EDWARD ORTON, JR., CERAMIC FOUNDATION BALANCE SHEET*

JANUARY 1 TO DECEMBER 31, 1938

ASSETS			
Cash		$ 2,770.11	
Accounts receivable	$ 7,045.14		
Less reserve for bad accounts	311.15	6,733.99	
Saving accounts		855.12	
Reserve invested		13,681.43	
Postage		56.95	$ 24,097.60
Raw materials		2,688.31	
Cone powder		6,256.35	
Finished goods		9,977.87	
Packing boxes, labels		351.38	
Shipping supplies		428.05	19,701.96
Prepaid insurance		135.23	
Prepaid freight		143.12	278.35
Land		22,919.46	
Building	79,870.74		
Less reserve for depreciation	15,670.25	64,200.49	
Machinery and equipment	20,203.88		
Less reserve for depreciation	6,324.34	13,879.54	
Research equipment	4,149.52		
Less reserve for depreciation	2,630.75	1,518.77	
Office equipment	2,762.66		
Less reserve for depreciation	2,029.80	732.86	103,251.12
TOTAL ASSETS			$147,329.03

BALANCE SHEET DECEMBER 31, 1938

LIABILITIES AND NET WORTH ACCOUNTS			
Liabilities			
Accounts payable (current)		$ 355.78	
Accrued payroll (current)		253.00	
Unemployment insurance reserve		277.27	
Old-age pension reserve		140.28	
Calif. sales tax		39.07	
Calif. postage			
Accrued interest on mortgage		171.96	$ 1,237.36
Fellowships			1,000.00
Loans payable			10,740.00
Annuities: Mrs. Orton			
Certain		8,245.93	
Life		47,766.20	56,012.13
TOTAL LIABILITIES			68,989.49
Net worth accounts			
Balance January 1	$71,228.18		
Plus refund income tax	$550.02		
Plus adjusted monument account	453.50	1,003.52	72,231.70
Net profit to date	9,107.84		6,107.84
Less profit to Fellowship	3,000.00		
Total Net Worth Account			78,339.54
Total Liabilities and Net Worth Accounts			$147,329.03

* The Balance Sheet for 1937 was published in *Bull. Amer. Ceram. Soc.*, **17** [3] 144 (1938).

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Kryolith
Lead Chromate
Magnesium Carbonate
Manganese Dioxide
Nickel Oxide, Black
Nickel Oxide, Gray
Nickel Sulphate
Potassium Bichromate
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